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BETWEEN HOPE AND FEAR:
THE PSYCHOLOGY OF RISK

LOLA L. LOPES

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Psychophysical theories of risk (e.g., Bernoullian utility theory, prospect theory) are compared with motivational theories (e.g., those of McClelland and Atkinson). A new theory is proposed that describes risk taking in terms of two factors: Factor 1 is a dispositional variable involving motivation for security versus potential. This factor distinguishes risk averse and risk seeking individuals and

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reflects primarily whether the individual is motivated to avoid bad outcomes or to achieve good outcomes. Factor 2 is a situational variable involving current level of aspiration. Level of aspiration reflects immediate needs and opportunities. In the theory, these two factors are sometimes in correspondence and sometimes in conflict, predicting complex patterns of data. Evidence is presented to support the theory and the relationship of the theory to other concepts (e.g., safety-first, disappointment, regret, emotion, aesthetics) is discussed.

Between Hope and Fear:
The Psychology of Risk

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In press:
Advances in Experimental Social Psychology

(Contents)

I. Introduction

Most things begin to look a little funny if you stare at them long enough. So too the psychology of risk. What is most disconcerting is that there is so much theory for so little substance. Countless hours have been spent by psychologists and economists alike in trying to explain theoretically why people buy both lottery tickets and insurance. Lottery tickets cost a dollar. One. We buy insurance (when we can afford it) so that we can sleep better. Is it really so strange that we should want to buy both?

This article is about risk: what risk is (if it is any thing at all); how people think about it; what they feel about it; and what they do about it. The article is also about how psychologists think about risk: how they study it; what tasks they use; what factors they vary; and what models they build (or borrow) to describe people's behavior.

Technically, the word risk refers to situations in which a decision is made whose consequences depend on the outcomes of future events having known probabilities. Choices among the different kinds of bets in games like roulette and craps are good examples of choices made under risk. Insurance companies also operate under risk when they set the premiums for ordinary life insurance. But most of the time our knowledge of probabilities is not so exact. Sometimes it's pretty good (as with the weather tomorrow or the going rates for auto loans just now); other times it's pretty awful (as with whether a wedding reception should be held indoors or outdoors several months hence or whether the fixed rate mortgage that's offered today is going to feel like a bargain or a burden 10 years down the road). When our knowledge of probabilities is very inexact (or lacking entirely) we say that decisions are made under uncertainty or ignorance. Obviously, risk shades into ignorance and most important decisions are made part way between the poles.

Psychological studies of risky choice (which is the term used conventionally to refer to all but the most extreme instances of ignorance or ambiguity) fall into two groups. At one extreme are the studies run by mathematically inclined experimental psychologists. These are studies in which subjects make decisions about gambles which are described in terms of amounts and probabilities. At the other extreme are studies run by personality psychologists who are mostly interested in individual differences in risk taking. Their tasks tend to be closer to everyday experience and they often involve elements both of chance and skill.

A. The Experimentalists' View

A good example of an experimental task comes from Kahneman and Tversky (1979) who asked subjects questions similar to this: which would you rather have, $3,000 for sure or an 80% chance of winning $4,000? Most subjects prefer the $3,000 for sure even though the expected value of the gamble is higher, .80 x $4,000 = $3,200. Such preferences are conventionally labeled "risk averse" as are preferences favoring a 90% chance of winning $3,000 over a 45% chance of winning $6,000.

Experimental psychologists tend to explain risk averse behavior in one of two ways. Some theories of risky choice see the subject as trading off

potential return with "risk," a construct that is most often identified with variability in the outcome distribution. For example, Coombs's (1975) "portfolio theory" is based on the premise that choices among risks reflect a compromise between maximizing expected value and achieving an individually determined ideal level of risk. Thus, investors who prefer low risk must accept the lower but safer returns associated with bonds whereas investors who prefer more risk can opt for the higher but less safe returns of stocks and commodities.

Theories that consider risk to be a function of the variability among potential outcomes are intuitively appealing, but they are less commonly held than alternative theories based on weighted value models, the best known of which is expected utility theory. In expected utility theory, subjects are assumed to "compute" something similar to an expected value, but instead of using the objective dollar amounts, they operate on subjective amounts (or utilities) which are usually nonlinearly related to dollar amounts.

The first use of the utility concept was made by Daniel Bernoulli in 1738. He argued that the value of money is not absolute, but depends on how much one has already: "Any increase in wealth, no matter how insignificant, will always result in an increase in utility which is inversely proportionate to the quantity of goods already possessed" (Bernoulli 1967, p. 25). This view implies that a constant gain, say $1000, will be worth more subjectively to a poor person than a rich person. It also implies that subjective differences between amounts of money that differ by a constant get smaller as the absolute magnitudes of the amounts get larger. In other words, there's more difference psychologically between $1,000 and $2,000, say, than betweeen $10,000 and $11,000. In Bernoullian terms, money has _marginally decreasing utility_ (which is short for saying that the subjective value of constant increments gets smaller and smaller). In mathematical terms, the utility function (which relates the objective value of money to its subjective value) is negatively accelerated. An example of a negatively accelerated utility function is shown in the upper left quadrant of Figure 1.

Insert Figure 1 about here

Bernoulli's utility theory predicts risk aversion. This is easy to understand intuitively. Consider a gamble that offers a .5 chance of winning $2,000 and a .5 chance of winning nothing. The expected value of the gamble is $1,000, but it is worth less subjectively to anyone having a Bernoullian utility function. This is because the subjective value of $1,000 is more than half the distance between nothing and $2,000. Thus, the utility of $1,000 for sure must be greater than the _average_ of the utility of nothing and the utility of $2,000 (which is all that the expected utility is -- an average in which utilities are weighted by their probability of occurrence).

A problem, however, is that people are not always risk averse. For example, they buy lottery tickets even though it is well known that, on .verage, lotteries are mathematically unfair (which doesn't mean, of course, that they are crooked, but only that the price of the ticket is more than the expected value). People are also sometimes "risk seeking" (as it is conventional to say) when choosing among risks that have negative consequences

(Markowitz, 1959; Williams, 1966; Kahneman & Tversky, 1979). For example, many people would prefer to face an 80% chance of losing $4,000 than to lose $3,000 for sure even though the expected value of the risky loss ($3,200) is greater than the sure loss.

Risk seeking choices can be explained by weighted value theories in two different ways. One way is to say that the utility function is not always negatively accelerated, but instead has one or more regions of positive acceleration. Three examples of such kinky utility functions are shown in Figure 1. The function in the upper right quadrant was proposed by Friedman and Savage (1948), that in the lower left by Markowitz (1952), and that in the lower right by Kahneman and Tversky (1979)[1]. Each of these functions has one or more regions of negative acceleration (which predict risk averse behavior such as the purchase of insurance and the rejection of gambles) and one or more regions of positive acceleration (which predict risk seeking behavior such as the purchase of gambles, notably long shots that offer very large prizes at very small probabilities).

Another way to explain risk seeking choices is to suppose that the weights people use in evaluating gambles are not identical to the objective probabilities. Thus, people may purchase lottery tickets because they (optimistically) assign more weight to the probability of winning than is justified objectively. This notion that subjective probabilities may differ from stated probabilities is consistent with subjectively expected utility theory (Savage, 1954). It is also consistent with more general weighted utility models (Karmarkar, 1978; Kahneman & Tversky, 1979) in which the subjective values attached to probabilities don't even act like probabilities.

To sum up, then, most experimentalists explain risky choice by positing an internal process for evaluating gambles that is structurally similar to computing expected values. However, the objective values are replaced by subjective values such as utilities and probability weights that differ quantitatively from their objective counterparts.

B. The Personologists' View

A good example of a task used by personality psychologists is the "ring toss" game originally used by McClelland (1958) in his studies of achievement motivation. In this task, subjects throw rings onto a peg from a distance that they are allowed to choose themselves. At one extreme, they can stand so near the peg that success is virtually certain. At the other extreme, they can stand so far away that success is virtually impossible. The variable of interest, therefore, is not how well they do objectively, but rather where they stand.

This is a task in risky choice (even though the probabilities are only roughly known) because subjects are choosing among alternative actions that have the character of gambles. One can choose (and some do) to stand near the peg in which case the probability is high, but the personal satisfaction in getting the ring over the peg is small. Alternatively, one can stand further back in which case the probability is smaller but the satisfaction is greater. One can even choose a long shot (literally) in which the probability is virtually nil, but the potential satisfaction is enormous. (Consider the

heady burst of satisfaction that comes in basketball when a desperation shot, tossed the full length of the court, drops neatly through the net. It helps, of course, if it is one's own team that has made the shot.)

Personologists explain people's choices in the ring toss game in terms of their motivations (McClelland, 1961; J. Atkinson, 1983). People who have high motivation to succeed (M_s) tend to pick intermediate distances (particularly if they are also low in the motive to avoid failure, M_{af}). The theoretical rationale for this is that there is a three-way multiplicative relation between motivation, probability, and incentive (J. Atkinson, 1957). Since probability of success (closeness to the peg) and incentive value (anticipated satisfaction from making the particular shot) are inversely related to one another, the attractiveness of the task for the person with high M_s and low M_{af} is least when the probability of succeeding is either very small or very large, and it is maximum when probability is at an intermediate value[2].

People who are low in M_s, however, especially if they are also high in M_{af}, more often stand either very near or very far from the peg. Either way, these people reduce their performance anxiety by virtually guaranteeing that they will experience either the tepid success of a trivial accomplishment or the denatured failure of not doing something that can't be done anyway except by sheer good luck.

Thus, personologists focus on the similarities and differences between different people's needs and on the various options that people pursue for meeting their needs. They also stress the often competitive nature of needs and the resulting compromises that must be made between certainty and incentive, for instance, or between the motive to achieve success and the motive to avoid failure (both of which can exist in the same person at the same time.)

II. Psychophysical versus Motivational Theories of Risk

The gamble task and the ring toss task appear to have little in common, but they are alike structurally. In each case the subject chooses among alternative options, each of which can be characterized by the probabilities and values that are attached to uncertain outcomes. In fact, one can with some justice interpret subjects' choices in the ring toss task as maximizing expected utility (cf. J. Atkinson, 1958). But there are profound differences in the theoretical mechanisms that have been used to explain subjects' choices in these two tasks.

Bernoullian theories are <u>psychophysical</u> in exactly the sense of ordinary sensory psychophysics. In fact, the quantitative function that Bernoulli suggested for utility reappeared more than 100 years later as Fechner's general psychophysical law. But this means that in Bernoullian theory, risk averse <u>behavior</u> has neither to do with <u>risk</u> nor with <u>aversion</u>. Instead, it has only to do with the way we experience quantity. The person who turns down an 80% chance of winning $4,000 in favor of a sure $3,000 is <u>not</u>, therefore, avoiding risk, nor even experiencing risk in any theoretically relevant way, but is only responding to the same sorts of factors that make the difference in heaviness between 1 pound and 2 pounds seem greater than the difference

between 10 pounds and 11 pounds.

The same can be said for theories in which objective probabilities are replaced by subjective probabilities or by probability weights. In fact, Kahneman and Tversky (1984) have referred to their decision weight function as reflecting the "psychophysics of chances" (p. 344). Their decision weights are assumed to differ from objective probabilities due to factors that are like those found in perception. For example, category-boundary effects make a change from impossibility to possibility (or from possibility to certainty) seem larger than a comparable change in the middle of the scale. This is the same sort of thing that happens in the "categorical perception" of human speech. Sounds that actually change in equal acoustic increments from an ideal "ba" to an ideal "da" are perceived to shift abruptly from sounding like clear ba's to sounding like clear da's (Liberman, Harris, Hoffman, & Griffith, 1957).

Motivational theories, on the other hand, construe the decision maker as analyzing possible outcomes and assessing risks (by which is usually meant simply the probability of achieving some goal). For example, McClelland (1961) gave the following account of how children who are high in achievement motivation decide where to stand:

> If they stand too close to the peg, they are much more likely to throw the ring on...but they are less likely to get any feelings of achievement satisfaction from doing so. If they stand too far away, they are both much less likely to succeed and more likely to regard success as "luck," than if they stand a moderate distance from the peg. In fact, they are behaving like the businessman who acts neither traditionally (no risk) nor like a gambler (extreme risk), but who chooses to operate in a way in which he is most likely to get achievement satisfaction (moderate risk, in this case about one chance in three of succeeding) (p. 212).

There are many places in McClelland's account where one could evoke psychophysical mechanisms to explain why children make different choices: they might attach different subjective values to success at different distances; or they might assign different probabilities to succeeding at a given distance; they might even differ in the way they perceive distances. But this is not how achievement theorists explain things. McClelland is careful to rule out such factors. For example, he acknowledges that children who are high in achievement motivation tend to perceive their probability of success more favorably than children with low achievement motivation, particularly when there is no evidence one way or the other. However, when they have reasonable knowledge based on past performance, they use that knowledge appropriately and do not display a greater perceived probability of success than children who are low in achievement motivation. In his words, achievement motivated children "are not impractical 'dreamers' overestimating their success at everything; instead they rely on facts so far as they are available, and then fall back on generalized self-confidence" (McClelland, 1961, p. 223).

One can also examine the possibility that achievement motivated children simply place higher subjective value on success by looking at their preferences in games of pure chance. In this situation they clearly prefer

the shortest odds they can get (the safest bets) followed by intermediate values. Children with low achievement motivation, on the other hand, tend to like long shots that offer large prizes, but at small probability (McClelland, 1961).

A. The Role of Cognition

We have, then, two different approaches to explaining risky choice, one primarily psychophysical and the other primarily motivational. The theories differ also in the degree to which they are <u>cognitive</u>. The motivational theories have strong cognitive components. In order to choose appropriately, task difficulty must be analyzed for the relative contributions of skill and chance, past experience must be marshalled and used to assess probabilities, goals must be set and future feelings predicted about what will be satisfying and what not. Thus, it is motivation that incites action and gives it direction (i.e., approach or avoidance), but it is cognition that guides action to its intended goal.

Psychophysical theories, on the other hand, have not been couched in cognitive terms, although they certainly might be. One could, for example, justify a Bernoullian utility function in terms of Maslow's (1954) notion of a need hierarchy. On this view, $1,000 really <u>is</u> worth more to a poor person than a rich person because the poor person will spend the money to satisfy more basic needs (food, shelter) whereas the rich person will spend it on more transcendent needs (operas, electronic running shoes). Likewise, people's tendency to treat small probabilities as zero might be justified cognitively in terms of the degree to which small probabilities can be expected to produce discernable impacts on how we choose to live our daily lives. This was done, in fact, by the early probabilist, Buffon, who urged that all probabilities less than .0001 be treated as "morally" (which is to say, psychologically) equal to zero (Daston, 1980).

This is not, however, how psychophysical theories are justified. Indeed, they tend most often not to be justified at all. But Kahneman and Tversky (1979) have been refreshingly clear about their theoretical foundations. They say of their value (or utility) function,

> Our perceptual apparatus is attuned to the evaluation of changes or differences rather than to the evaluation of absolute magnitudes. When we respond to attributes such as brightness, loudness, or temperature, the past and present context of experience defines an adaptation level, or reference point, and stimuli are perceived in relation to this reference point....Many sensory and perceptual dimensions share the property that the psychological response is a concave function of the magnitude of physical change....We propose that this principle applies in particular to the evaluation of monetary changes (pp. 278-279).

Likewise, their description of probability weighting, while less clearly articulated, seems to rest primarily on perceptual and attentional metaphors.

B. Risk-Taking Reconsidered

Personality psychologists and experimental psychologists tend to have very different goals. Personologists, at least traditionally (i.e., pre-Mischel, 1968) have taken an idiographic approach to explaining behavior. Thus, they have been concerned with the things that make us <u>different</u> from one another. Since these are necessarily attached to the individual and not to the situation (which is held constant), the theoretical emphasis has fallen on the structures and dynamics of the inner person. Experimentalists, on the other hand, have typically taken the nomothetic approach which is aimed at understanding Everyman and the ways in which we are all alike. This approach puts the emphasis on the commonly experienced environment which, in the context of the laboratory, reduces to the <u>stimulus</u>. Experimental theories, whether they are behavioral or cognitive, tend to revolve around the transformation of the stimulus into the response. If this can be done without invoking individual differences or higher level cognition, all the better. Hence the appeal of the psychophysical metaphor for explaining risky choice (or more properly, for explaining the most common choice pattern while ignoring entirely the patterns of a substantial minority of subjects).

When the scientific paths of personologists and experimentalists cross as they have in the area of risky choice, the weaknesses of each tradition are illuminated by the strengths of the other. Personality theorists paint with a broad brush and a richly hued palette, at least compared to their monochromatic experimental colleagues. McClelland's (1961) <u>The Achieving Society</u> is breathtaking in its scope and intent, ranging methodologically from the laboratory to the field and substantively from history to economics and from psychology to sociology. But the experimental evidence tends to be unsystematic and unconvincing, at least for the experimentalist schooled in the parametric (if you can vary it, vary it) tradition. Thus, although the motivational approach is appealing for its whole-person flavor (with motivation and emotion and cognition all having their place), the actual experiments are scattered far too sparingly over the conceptual domain. In particular, the motivational treatment of risk-taking in the domain of pure chance is disappointing, especially when one considers that we regularly deal with risks (e.g., farmers planting crops, investors choosing a stock) whose outcomes are largely out of our personal control.

Experimentalists, on the other hand, tend to explore their domain more thoroughly, not necessarily because they are better scientists, but because the tradition of looking for "critical tests" keeps the experimental stimulus changing in interesting ways. Thus, the history of thought in risky choice has proceeded in relatively discrete steps as paradoxical results posed initially as challenges to the theory eventually became accommodated via theoretical elaboration. (A comparison with Ptolemaic astronomy would not be unwarranted after 250 years of elaboration on a theory that has remained essentially unchanged structurally). But in the service of the detailed view, the big picture tends to be lost. So it is with risky choice; after all the study and all the clever theorizing, we are left with a theory of risk-taking that fails to mention risk. It also fails to consider (much less explain) the motivational and emotional factors that give risky choice its experiential texture: the hopes and fears that give us in due measure both purpose and pause.

In the remainder of this article, I present a theory of risky choice that attempts to meld the strengths of both approaches. Empirically and methodologically it is tied to the experimental approach to risky choice. But theoretically it is more strongly tied to motivational approaches, particularly those of McClelland (1961) and J. Atkinson (1983). Nevertheless, the theory was developed independently of the latter theories and has at least some formal roots in economics (see Lopes, 1984). Although the basic theoretical constructs of the new theory are quite similar to those found in the achievement literature, I will make no particular attempt to bring the two approaches into tighter theoretical alignment since that could (and probably would) do disservice to the fact that the task domains have important differences, particularly those involving the skill/chance dimension. However, the strong theoretical similarities increase my confidence in both approaches.

III. The Task and the Representation of the Stimulus

The term "risky choice" can be read two ways. Risky choices are choices that have an element of danger. They are risky and may come to a bad end. Losses may be sustained, hopes may be shattered, or opportunities wasted. Risky choices are also choices between risks or between risks and sure things. In this sense, risks are gambles. Most research on risk has concentrated on gambles in which there are only two possible outcomes. In fact, a not inconsiderable part of this research has dealt with what might be called one-outcome gambles in which one outcome represents a change (e.g., winning $4,000) and the other represents the <u>status quo</u>. The focus on two-outcome gambles seems reasonable to most researchers in part because such gambles lend themselves well to parametric manipulation in the laboratory. In addition, two-outcome gambles are conceptually simple, a fact of at least some consequence given the known limitations in human beings' ability to process information[3].

Real-world risks, on the other hand, hardly ever have just two outcomes. More often they range essentially continuously over the outcome variable. (Consider interest rates on Individual Retirement Accounts. As I write, they're averaging from around 7.5% for short term investments up to around 9.5% for long term investments. Is 9.5% enough to tie up funds for a long period, or will we have another bout of high interest rates? And if so, how high will they go?) In fact, two-outcome gambles occur mostly in the context of formal gambling (and psychology experiments). A $2 bet on red in roulette, for example, will either win $2 or lose $2. Likewise, a horse player betting $2 at odds of five to one will either win $8 or lose $2. In either case, however, it seems unlikely that players will make a separate decision each time they place a bet. Instead, the decision to play usually entails placing a series of bets, with resulting net outcomes that range in principle from all losses to all wins.

Insert Figure 2 about here

The experiments described in this article have investigated how people chose among multioutcome gambles (or "lotteries" as we refer to them with subjects). Figure 2 gives six examples of these lotteries listed in the order in which they are preferred by risk averse subjects (Schneider & Lopes, in press): riskless > short shot > peaked > rectangular > bimodal > long shot. Each of the lotteries has 100 lottery tickets (represented by tally marks) and each has an expected value of approximately $100. The lotteries differ, however, in how the prizes are distributed. The long shot, for example, has 31 tickets that each win nothing, 22 tickets that each win $49, and so forth up to a single ticket that wins $439. In contrast, the short shot has only 1 ticket that wins nothing, 2 tickets that each win $13, and so forth up to 31 tickets that each win $130. (Note that the riskless lottery is so named because it has a riskless, i.e., sure, component that guarantees, in this case, a minimum win of $70.)

All the lotteries in the figure are "gain" lotteries which means that their prizes are all ≥ 0. Loss lotteries were also used in some of the experiments. Loss lotteries are just like gain lotteries except that their outcomes are negative. Thus, for example, the long shot for losses has 31 tickets that each lose zero, 22 tickets that each lose $49, and so forth down to 1 ticket that loses $439. Likewise, the riskless loss lottery guarantees a riskless (sure) loss of at least $70.

Three kinds of task have been used. In the most common task subjects were shown pairs of lotteries in all possible combinations and asked which they would prefer if they were allowed a free draw from either (Lopes, 1984, Experiments 1 and 2; Schneider & Lopes, in press). Pair-preference data can be used to infer preference orders over the entire set of stimuli. The second kind of task involved judgments of riskiness also expressed in pair-choices (Lopes, 1984, Experiments 3 through 6). These can be used to infer risk orders (which are not the same as preference orders except for risk averse people). The third kind of task (Lopes, 1986) was embedded in a standard pair-preference task. Subjects were shown pairs of lotteries and asked to express their preferences for each. For a subset, however, they were also asked to explain their preferences in writing. These written protocols were collected for a group of 14 graduate students from a variety of departments. In order to avoid the known pitfalls of retrospective reports (Ericsson & Simon, 1980), the protocols were obtained directly at the point of choice.

The present article focuses primarily on preference data from Lopes (1984) and Schneider and Lopes (in press). Examples of the verbal protocols are used throughout, however, for illustration. In the protocols lotteries are referenced by the names listed in Figure 1. These names were not, however, used by the subjects.

A. How Can We Represent Risks?

One of the most important steps in psychological theorizing is to find a representation of the stimulus that has psychological fidelity, by which I mean a representation that highlights the stimulus features that actually affect behavior. For the most part, two-outcome gambles have been treated as though the functional stimulus is identical with the presented stimulus: a pair of outcomes each associated with a probability of occurrence. For lotteries like those in Figure 1, however, we seem to respond more to the shapes of lotteries than to the amounts and probabilities of individual outcomes.

The idea that risk is a function of shape has been proposed both for theories of risk perception (Luce, 1980; Pollatsek & Tversky, 1970) and for theories of risk preference (Allais, 1979; Coombs, 1975; Hagen, 1969; Markowitz, 1959). In these theories, shape is identified with the statistical moments of the distributions, particularly mean, variance, and skewness[4]. Variance is generally considered to be bad (i.e., risky) whereas positive skewness (a predominance of low outcomes with a few high outcomes) has been identified with hope and negative skewness (a predominance of high outcomes with a few low outcomes) has been identified with fear (Hagen, 1969). In this view preference for the short shot over the long shot would be interpreted as due to the short shot's much lower variance. Likewise, preference for the riskless lottery over the short shot would be interpreted as a preference for positive skewness since these lotteries have equal variance.

Moments models have several virtues, not the least of which is that any distribution can be described, in principle, to any desired level of precision by a sufficiently large set of its moments. But they also have major difficulties. Some of these are technical as, for instance, the fact that, subjectively speaking, risk doesn't really act like variance[5]. More serious, however, is that such theories implicitly assume that moments have independent psychological reality. That seems doubtful except for the simplest comparisons. It is not all that easy to intuit the relative variance of lotteries that differ in skewness (e.g, the peaked lottery versus the short shot) except when the differences are very great (e.g., the peaked lottery versus the long shot).

In the present theory, lotteries are represented by cumulative graphs called Lorenz curves that are used in economics to show how wealth is distributed among people. Welfare economists find them useful for saying things like "The poorest 20% of the population in Country X have less of their country's wealth than the poorest 20% in Country Y." What is relevant for us is that subjects tend to talk as though they also view lotteries in cumulative terms. Here, for example, are reasons given by three typically risk averse subjects for why, in a forced choice between the short shot and the long shot, they prefer the short shot (Lopes, 1986):

> I'd rather have greater chances of winning a little something than greater chances for nothing. The triple jackpot [in the long shot] doesn't make me want to go for it cuz the odds are too great. (Subject #10)

> I choose the [short shot] because there is only one chance of me

> losing and the best odds indicate a good chance of winning $71 or more. The [long shot] has too many opportunities to lose -- it is too risky. (Subject #7)
>
> In the [long shot], 32% do better than the best in the [short shot], but 31% get nothing at all. The [short shot] is the better risk. (Subject #14)

Notice the inequalities: the keynote of these protocols is the cumulative likelihood of meeting or exceeding a goal (e.g., "greater chances of winning a little something," "a good chance of winning $71 or more," "do better than the best"). The protocols also suggest that the subjects are mostly concerned about doing badly (getting zero or a small amount).

Here for comparison are protocols from three subjects who chose the long shot. These subjects were among the most risk seeking of the group. Note their clear focus on the long shot's large prizes.

> The chance for winning nothing is small with the [short shot] but since the dollar amount in the [long shot] is attractive I run the risk of losing and go for the [long shot]. (Subject #12)
>
> The top prize money of the [long shot] is better. You still have a good chance of winning some money in the [long shot] as well as having a shot at the top prize money. The in between prize money in the [long shot] is not all that bad, and is greater than the top prize money of the [short shot]. (Subject #9)
>
> I'll take the added risks of losing it all or getting a lower number for the chance of the higher prizes. Therefore I'll pick the [long shot]. (Subject #11)

B. How to Draw a Lorenz Curve (and Why)

Lorenz curves are convenient for looking at lotteries cumulatively and for comparing lotteries selectively on either low outcomes or high outcomes. They also highlight differences and similarities among lotteries that are not immediately apparent by direct inspection of the lotteries. Figure 3 shows how a Lorenz curve is graphed. Column 1 at the left shows the prizes for the peaked lottery ordered from the least (at the top) to the most (at the bottom). Column 2 gives the number of tickets at each level and column 3 converts these into probabilities. Column 4 is the product of columns 1 and 2 (which is the total prize money at each level). Columns 5 and 6 are running sums of columns 3 and 4, respectively, and column 7 is column 6 divided by the total prize money. This gives the cumulative proportion of prize money at each level[6].

Insert Figure 3 about here

The Lorenz curve is plotted at the right. The abscissa gives the cumulative probability (column 3) and the ordinate gives the cumulative proportion of prize money (column 7). Notice that the Lorenz curve runs from the lower left (the low or "bad" end of the curve representing tickets with small prizes) to the upper right (the high or "good" end of the curve representing tickets with big prizes). If every ticket in the lottery were a $100 sure thing, the Lorenz curve would fall on the diagonal. To the extent that the tickets have unequal prizes, the Lorenz curve bows away from the diagonal.

Insert Figure 4 about here

Figure 4 gives the Lorenz curves for the long shot and the short shot. Notice that the curve for the long shot lies everywhere <u>below</u> the curve for the short shot. This is the sign of large relative dispersion. The long shot's several large outcomes (indicated by the steepness of the curve at the upper end) must be paid for by its many zero and small outcomes (indicated by the flatness of the curve at the lower end). The Lorenz curve for the short shot, on the other hand, lies nearer the diagonal since it has no really large outcomes and only a few small outcomes. These considerations lead directly to a simple rule for choosing between lotteries: people who want to avoid the <u>worst</u> outcomes should prefer lotteries whose Lorenz curves lie <u>near</u> the diagonal at the <u>low</u> end (stippled area at lower left), and people who want to have a go at the <u>best</u> outcomes (at least as good a go as can be gotten) should prefer lotteries whose Lorenz curves lie <u>far</u> from the diagonal at the <u>high</u> end (striped area).

Insert Figure 5 about here

Figure 5 shows the Lorenz curves for the short shot and the riskless lottery. These make an interesting comparison because their Lorenz curves cross one another: the curve for the riskless lottery is nearer the diagonal at the low end (stippled area lower left), but further away at the high end (striped area upper right). Thus, the riskless lottery offers both higher minima <u>and</u> higher maxima. Not surprisingly, it appeals to both kinds of subjects. Here are subject #10 (risk averse) and subject #11 (risk seeking) from Lopes (1986) explaining why they chose the riskless lottery:

> The [riskless lottery] has (1) a higher jackpot (2) greater chance of winning a larger amount <u>under</u> $100. I look at the highest amount I could lose rather than the highest amount I could win. (Subject #10)
>
> I picked the [riskless lottery] because both the minimum and the maximum amounts are more, and because for both there's a good chance of getting around $100. (Subject #11)

Insert Figure 6 about here

Figure 6 gives Lorenz curves for the bimodal lottery and the long shot. These lotteries (which look very different superficially) are similar at their low ends (lots of small outcomes) but differ markedly at their high ends (lots of moderately large outcomes versus a few <u>really</u> large outcomes). People who want to avoid low outcomes should have a mild preference for the bimodal lottery since it lies a little nearer to the diagonal at the low end. People who want to win large outcomes, however, should have a relatively strong preference for the long shot since its Lorenz curve lies quite a bit further from the diagonal at the high end. This is exactly what happens (Lopes, 1984; Schneider & Lopes, in press). The pattern is illustrated by the following two protocols from Lopes (1986), the former expressing a mild preference for the bimodal lottery and the latter expressing a stronger preference for the long shot:

> I chose the [bimodal lottery], because there seems to be twice as much chance to get nothing in the [long shot]. Unfortunately, there's a 50% chance of getting less than $100 in the [bimodal lottery]. The [long shot] also has higher stakes. However, all those zeros worry me. (Subject #5)

> [Took long shot] because (1) very hi win possible, (2) chance of winning > $100 about same as for other distribution. [The bimodal lottery] has too little possible gain for the hi risk of winning nothing. (Subject #6)

Insert Figure 7 about here

Lorenz curves can also be used to describe loss lotteries. The only thing that needs to be remembered is that for losses, the <u>best</u> (biggest) outcome is zero. (Not hard to remember when real losses are being considered!) Figure 7 gives the Lorenz curves for the bimodal loss lottery and the long shot loss lottery. Although they look a little different than Lorenz curves for gain lotteries (the curves now being <u>above</u> the diagonal), they are read in exactly the same way. Cumulative probability still runs from 0 at the left to 1 at the right and cumulative proportion of value still runs from the smallest value at the bottom (<u>minus</u> 1) to the largest value at the top (zero). The worst outcomes are still in the lower left corner and the best outcomes are still in the upper right corner. If all the tickets were for a $100 loss, the Lorenz curve would fall on the diagonal.

The rule for choosing also stays the same: people who want to avoid the worst outcomes (big losses) should prefer lotteries whose Lorenz curves lie <u>near</u> the diagonal at the low (bad) end (stippled area); people who want to obtain the best outcomes (small losses) should prefer lotteries whose Lorenz curves lie <u>far</u> from the diagonal at the high (good) end (striped area).

These different reasoning patterns can be seen clearly in subjects' protocols. Here for example are two typically risk averse subjects from Lopes (1986) explaining why they prefer the bimodal loss lottery to the long shot

loss lottery:

> With the [bimodal lottery], the most that I can lose is $200. With the [long shot], I could lose $439. (Subject #2)

> I would not risk losing $439, or even $292 and up. (Subject #3)

In contrast, here is a subject who chooses the long shot:

> I choose the [long shot] because there is a preponderance of tickets that can incur no loss, and a fair number of other tickets that could lose less than $98. In the [bimodal lottery] 50% of the tickets do stand to lose $93 or less but there are fewer that can promise to cause no financial loss. I notice that there are large amounts to be lost if one is unlucky, but the chances of being unlucky are somewhat slimmer in the [long shot]. (Subject #1)

Negative lotteries are particularly interesting because they often present difficult choices. Here, for example, is a subject who has chosen the peaked loss lottery over the rectangular loss lottery:

> I go back and forth on this, the gain on improving the chances on a low loss increases the chance of a higher loss. I pick the [peaked lottery] to try to reduce the higher loss. (Subject #11)

Another subject, however, chooses to gamble on the long shot rather than take a sure $100 loss:

> In the [sure thing] no way could I lose more than $100. But no way could I lose less, either. In the [long shot] there are enough chances to lose less than $100 to justify losing a lot more. I'll go ahead and see if I can get less than $100 loss -- maybe even zero loss -- rather than accept a sure loss of $100. If I lose $100 I might as well lose $439. I don't like it either way. However, the [chances] of losing $439 or $390 or $341 -- etc. down to $146 are quite high. But so are zero, $49, or $98 or $146. So I'll take the chance. I don't feel great about it, though. (Subject #13)

Conflicts such as these are relatively common for loss lotteries. This is important because it suggests the existence of an additional factor in risky choice that is not captured by the Lorenz curve analysis. This factor will be discussed below.

Insert Figure 8 about here

Finally, Lorenz curves for loss lotteries can also cross one another producing agreement in choice between risk averse and risk seeking individuals. Figure 8 shows the Lorenz curves for the riskless loss lottery and the short shot loss lottery. Below are protocols from the same two subjects (the former risk averse and the latter risk seeking) who previously defended their choice of the riskless lottery over the short shot for gains. Below they tell why they <u>reject</u> the riskless lottery for losses:

> [Took short shot because] (1) there is a greater chance of losing $130 or more with the [riskless lottery]. (2) There is a greater chance of losing less than $70 in the [short shot]. (Subject #10)
>
> I pick the [short shot] because the maximum loss is less and because you may be able to hit as low as zero loss. No matter what, you lose $70 and possibly $200 in the [riskless lottery] -- too much risk. (Subject #11)

To sum up, Lorenz curves have at least four virtues for representing lotteries. First, being cumulative, they reflect the fact that subjects tend to evaluate lotteries in terms of inequalities. Second, they facilitate comparison of the particular regions in lotteries that appear to be salient to people with different goals. Third, they suggest similarities and differences among lotteries that, although they may seem obvious in retrospect, do not easily come to mind from inspection of the lotteries themselves. Fourth, they predict when people having different goals will agree (or disagree) about lotteries and when differences will be relatively large (or small). These are no small virtues for a stimulus representation. But that is all that Lorenz curves are: a way of representing lotteries. It is not to be supposed that people convert risks into "mental Lorenz curves". Clearly, they do not. The purpose of the Lorenz curve representation is to deepen understanding of the functional stimulus and to help us psychologists see (literally) what it is that people focus on when they compare lotteries.

IV. A Two-Factor Theory for Risky Choice

Until fairly recently, personologists focused largely on variables inside the skin, leaving experimentalists to deal with situational variables. Lately, however, personologists have come to agree with Mischel's judgment that "traditional trait-state conceptualizations of personality, while often paying lip service to man's complexity and to the uniqueness of each person, in fact lead to a grossly oversimplified view that misses both the richness and the uniqueness of individual lives" (Mischel, 1968, p. 301). Nevertheless, it is clear that "while stimuli or situations come to evoke and maintain behavior patterns, they do not respond by themselves" (Mischel, 1968, p 295). Behavior has sources both inner and outer. We are disposed by our unique constitutions and histories to behave in certain ways, but it is "situational stimuli that evoke [our responses], and it is changes in conditions that alter them" (Mischel, p. 296).

Two-factor theory uses both a dispositional factor and a situational factor to explain risky choice. The dispositional factor describes the underlying motives that dispose people to be generally oriented to achieving security (i.e., risk averse in conventional terminology) or to exploiting potential (i.e., risk seeking in conventional terminology). The situational factor describes people's responses to immediate needs and opportunities. As will be shown, these factors are sometimes in conflict and sometimes in concert, producing complex patterns of behavior in which risk averse choices

and risk seeking choices exist side by side in the same individual's behavior.

A. Factor 1: Security versus Potential

In an earlier article (Lopes, 1984), I argued that risk averse and risk seeking individuals differ in whether they pay most attention to the worst outcomes in a distribution or the best outcomes. Risk averse people appear to be motivated by a desire for <u>security</u> whereas risk seeking people appear to be motivated by a desire for <u>potential</u>. The former motive values safety and the latter, opportunity.

In mathematical terms, security motivation corresponds to weighting the worst outcomes in a lottery more heavily than the best outcomes and potential motivation corresponds to the opposite. Such processes could be modeled mathematically by applying appropriate weights to the cumulative functions that constitute the data for Lorenz curves. Indeed, there are several functions currently in use by welfare economists that could be used to quantify risk averse and risk seeking preferences (A. Atkinson, 1970; Dahlby, 1985). Describing these functions will not be necessary for present purposes, however, since raw Lorenz curves show all we need to know.

There are, however, two general points that should be made about weighting. First, weights in the theory are joint functions of the magnitudes of probabilities <u>and</u> the magnitudes of the outcomes to which they are attached. This is a fundamental departure from the family of weighted value models since in those models, probability and value are independent. Second, weights reflect individuals' <u>goals</u> and not their perception of probabilities or values. Thus, the fact that a person chooses, for example, to minimize the likelihood of a bad outcome does not imply either that (subjectively) he underestimates the value of good outcomes or that he overestimates the probability of bad outcomes. Although psychophysical effects may occur in either the money or the probability domain, these are considered to be of secondary importance in determining risky choice.

The security/potential factor is conceived to be a dispositional variable, reflecting the way individuals typically respond to risks. Not surprisingly, security motivation (risk aversion) is the far more common pattern (see Lopes, 1984; Schneider & Lopes, in press), so common, in fact, that economists have considered it to be the pattern for Everyman (Arrow, 1971; Pratt, 1964). This is probably not due to chance. Standards of prudence are passed from parent to child in the normal course of growing up. If that is not enough, hard experience informs us in no uncertain terms that, as Damon Runyan said, "the race is not always to the swift nor the battle to the strong, but that's the way to bet" (cited in Ellsberg, 1961, p. 644). Risk seekers, on the other hand, may dog the long shots, waiting (as a famous risk seeker once said) for "that one streak of luck, properly ridden and encouraged," to compensate them for all the bad times (Thackrey, 1968, p. 67, quoting Nick the Greek).

It should also be noted that the fact that someone is primarily motivated by one of the poles of the security/potential dimension does not imply that they are unaware of the other pole. It is better to think of these opposing tendencies as existing in some strength in everyone (as do M_s and M_{af} in

Atkinson's, 1983, theory), but with potential much less important than security and aspiration for risk averse people and security much less important than potential and aspiration for risk seeking people. Such weak motives would tend to come into play primarily when the stronger motives were insufficient to determine choice.

B. Factor 2: Aspiration Level

The security/potential factor reflects the way that a person usually looks at risks. Risk averse people look more at the downside and risk seekers more at the upside. But risk seekers may play it safe from time to time, and even the most risk averse person will take chances -- even big chances -- when necessary. Aspiration level (Lopes, 1983; Siegel, 1957; Simon, 1955) is a situational variable that reflects the opportunities at hand ("What can I get?") as well as the constraints imposed by the environment ("What do I need?")

The aspiration level that functions in any given situation (including the present task situation) can reflect at least three different sources. The first is the direct assessment of what is reasonable or safe to hope for. For illustration, here is a subject from Lopes (1986) who has rejected the short shot in favor of the peaked lottery:

> The chances are in the [peaked] lottery that I will get something close to $100, and I might get much more. I don't know why [I should] let $130 be the top limit when there's a reasonable chance of nearing $100 and a possibility for more. (Subject #3)

The next subject has chosen the riskless lottery in preference to a $100 sure thing:

> Since I am assured of winning something I am willing to risk a moderate amount for the possibility of a substantially greater amount. (Subject #4)

In both these cases, the subjects have taken the riskier option, but not before assuring themselves that it's prudent to shoot for its somewhat higher prizes.

The second source of aspiration levels is the direct contextual influence of the other alternatives in the choice set. Here, for example, is a subject choosing between the short shot and the riskless lottery:

> I chose the [riskless lottery] because I am assured of winning at least $70. In addition, I have a better than even chance of winning more than $70. It is the assurance of winning $70 that appeals to me. (Subject #7)

Based on this rationale, the subject's aspiration level appears to be no higher than $70. However, when the same subject is given a choice between a sure $100 (the sure thing) and the riskless lottery she says,

> I chose the [sure thing] because I would rather take the $100 as a sure thing than risk winning less. The other lottery also offers a sure thing ($70 at the least), however, the chances of winning less than $100 are about 50-50 in that lottery, so I opt for the safe bet of $100, a sure thing. (Subject #7)

The same shifting of aspiration level also occurs for losses. Here are two more protocols from the previous subject. In the first she rejects the long shot loss lottery in favor of the short shot. In the second she accepts the long shot in favor of a sure $100 loss:

> I chose the [short shot] because the most I could lose would be $130 and that seems safer than the [long shot]. Also the odds in both lotteries seem to favor a loss of between $50-$150, so I figure the lottery which has the lowest ceiling on a possible loss is the safest risk. (Subject #7)

> A $100 loss up front is too hard for me to swallow -- I chose the [long shot] as it allows for many chances to lose <u>less</u> than $100. True, the maximum loss could be as high as $439, but it is still a risk I am willing to take. (Subject #7)

Notice that the subject seems to switch from considering a $130 loss to be acceptable to considering a $100 loss to be unacceptable. Statements like these make it clear that sure things have a powerful influence in organizing choice, and the same seems to be true of values that are highly likely, though not certain.

The seemingly special status of certainty in risky choice has received a prominent role in several theories (Allais, 1979; Kahneman & Tversky, 1979; Machina, 1982), but the mechanism through which certainty effects operate is as yet unclear. One possibility (Kahneman & Tversky, 1979) is that they are instances of subjective category-boundary effects in the perception of probability (see Section II). Another possibility, however, is that certainty <u>is</u> objectively special since it permits planning to proceed unimpeded by uncertainty about outcomes that may not be resolved in the near future (see Section VI.C).

The third way that aspiration levels get set is by outside influence. A study currently in progress (Lopes & Casey, 1986) is looking at the role of necessity in a risk-taking task. In the task, subjects play a competitive game involving multioutcome lotteries against an opponent (either a computer or another real subject). In the game, players attempt to take or defend territory on a game board by choosing among moves that have distributions of possible outcomes similar to the lotteries in Figure 2. Although the data are not completely analyzed, we have noted a tendency for subjects to prefer riskier moves when they are in a bad position near the end of a round. This is as it should be: if there is little or no chance that the safer option will yield sufficient territory for a win within the number of moves remaining, the riskier option may be the probabilistically best choice (i.e., more likely to yield a winning outcome)[7].

Finally, it should be noted that although aspiration level is situational, it probably interacts with the security/potential factor, with security motivated people tending to set more modest aspiration levels than potential motivated people for both gains and losses. This possible interaction necessarily complicates the independent assessment of the contributions of security/potential and aspiration to risky choice. Nevertheless, support for the conceptual distinction between the two factors exists in the fact that, as will be seen, the factors often act in opposition to one another.

Conflict Between Security/Potential and Aspiration

A simple truth: you can't have it all. Corollary: you want more than you can have. Conflict is in the nature of things. All resources are limited (wealth, youth, even free lottery tickets), so people get plenty of practice juggling inconsistent desires and jury-rigging tolerable compromises.

Conflict arises in two places in the present theory. One, obviously, is the conflict between security and potential. It is a truism in the investment world that risk and return go together. If you want safety, you pay for it in yield; if you want yield you pay for it in worry. To say that security/potential defines a dispositional variable is to say that people typically choose one way or the other between avoiding bad outcomes and approaching good outcomes. But this does not mean that people do not see what they do not choose. In making a clear decision for, say, security, a person may acknowledge regretfully the loss of opportunity. People also are quick to notice the special benefits of choices such as the riskless lottery that allow them to have their cake and eat it too[8].

The second form of conflict is both more interesting and less obvious. These are the conflicts that can be created as different situations induce different patterns of agreement and disagreement between dispositional motives toward security or potential and the immediate needs and opportunities affecting aspiration level.

Consider someone who is dispositionally motivated to achieve security and suppose that, in the present task situation, the person has a modest aspiration level, say $50. Faced with the choice between the short shot and the long shot, the person would tend to reject the long shot on both counts: it is clearly less secure in Lorenz curve terms and it is also less likely to satisfy the aspiration level. The same would be true for almost any pair of gain lotteries. This is because there is a positive correlation between the ordering of the lotteries in terms of security and the ordering of the lotteries in terms of the probability that they will achieve the aspiration level.

For losses, however, there is a conflict between security and aspiration. Consider the same person choosing between the same two lotteries, but this time for losses, and suppose that the aspiration level is to lose no more than $50. The short shot is obviously more secure since its losses are capped at $130, but it is much less likely to yield a loss of $50 or less. This would

be true for almost any pair of loss lotteries: the ordering on security runs essentially opposite to the ordering on aspiration level.

For a potential motivated person, the situation would be just reversed. For losses, potential and aspiration level are positively correlated but for gains they are quite likely to be negatively correlated.

Conflict between security/potential and aspiration can produce quite complex patterns of data (see Coombs & Avrunin, 1983, for a general discussion of data patterns produced by conflict). Table 1 gives some values for illustration. The top of the table is for a risk averse individual and the bottom for a risk seeker. Gain choices are on the left and loss choices on the right. The aspiration level of the risk averse person is assumed to be $50 for both gains and losses whereas the aspiration level of the risk seeker is assumed to be $80 for gains and $20 for losses. These values are purely hypothetical, but they accord with our intuition that risk averse people probably have more modest aspiration levels than risk seekers.

Insert Table 1 about here

Let's begin with the risk averse person. Column 1 lists the six lotteries from Figure 1 plus a $100 sure thing. Columns 2 and 6 (AL) give the probabilities that the lotteries will yield the aspiration level: $50 or more for gains and $50 or less for losses. Columns 3 and 7 (SEC) give hypothetical values on security. (Keep in mind that the riskless lottery and the short shot change places as one goes from gains to losses.) These values range evenly between 1 for the sure thing and 0 for the long shot except for a tie in each ordering. (For gains, the worst outcomes in the short shot and the peaked lottery are almost identical in probability and value. Their Lorenz curves would be essentially superimposed at the low end. In the same way, for losses, the worst outcomes for the riskless lottery and the peaked lottery are almost identical. Their Lorenz curves would also be superimposed at the low end.)

Columns 4 and 8 (SEC x AL) show how security and aspiration are integrated. A multiplying rule is used because the choice is <u>conjunctive</u>. A lottery lacking good values on either security or aspiration will be rejected. The final two columns (REL PREF) simply normalize the products to a common base (by dividing by the sum of products) in order to allow an easier comparison of relative preference.

A similar analysis is given in the bottom of the table for the risk seeking person. Values for potential (POT) have replaced values for security, and the aspiration levels are now $80 or more for gains and $20 or less for losses. Note here that the ties in potential are now between the riskless lottery and the peaked lottery for gains and the short shot and the peaked lottery for losses.

Starting first with the risk averse person, note that relative preferences for gain lotteries tend to decrease from the sure thing to the long shot. This reflects the strong positive correlation between SEC and AL for gains ($\underline{r}$ = .97). For losses, however, there is an inverse-U pattern: preferences are low at the extremes but higher in the middle. This reflects

the strong negative correlation between AL and SEC for losses (_r_ = -.91).

For the risk seeker, the simple pattern occurs for losses: preferences tend to increase from the sure thing to the long shot reflecting the strong positive correlation between POT and AL for losses (_r_ = .92). For gains, however, the pattern is complex. The least preferred lotteries are the sure thing and the short shot and the most preferred are the bimodal, rectangular, and the long shot. This complexity reflects the negative correlation between POT and AL for gains (_r_ = -.97).

To sum up, the two-factor theory integrates a dispositional tendency to seek either security or potential with situationally driven aspiration levels. Security motivation captures the Bernoullian (1967) intuition that people are generally disposed to prefer sure things and gambles without large chances of bad outcomes. However, the theory handles equally directly the less prevalent tendency of some people to approach long shots and other gambles offering the unlikely possibility of large outcomes. In addition, the theory deals directly with situational circumstances that may cause a person to experience conflict between dispositionally driven preferences and externally driven goals. Thus, the theory explains how the person can be risk averse in the economic sense (i.e., typically preferring sure things) but sometimes make the same choices as someone who is ordinarily risk seeking.

V. Evidence for the Two-Factor Theory

A. Riskiness is the Absence of Security

The first bit of support for the two factor theory comes from judgments of riskiness. In Experiments 3 and 4 of Lopes (1984), subjects were shown pairs of gain lotteries and were asked to say which was the riskier. In virtually every case, the lottery judged to be the riskier was the one whose Lorenz curve lay further from the diagonal at the low end. The only exceptions involved the relative riskiness of riskless lotteries and short shots. (There were three examples of each). About half the subjects judged the riskless lotteries to be the riskier (contrary to the original expectation) and about half judged the opposite.

Experiments 5 and 6 of the same study suggested why this was so. In the former experiments, the term "risk" was left vague so that subjects could supply their own meanings. In the latter experiments, however, subjects were asked to select the lottery for which it would be riskier to pay $100. Under this condition, judgments for the other lotteries were virtually unchanged, but subjects were now nearly unanimous that the riskless lotteries were the riskier, a judgment that makes objective sense because there is a good chance that riskless lotteries will yield substantially less than $100 (e.g., $70). Apparently in the original experiment subjects adopted different aspiration levels. For most lotteries, riskiness does not depend on whether the aspiration level is low ($50) or high ($100), but for the riskless lotteries, the shift in aspiration is crucial.

The ability of the two factor theory to account for judgments of riskiness is a point in its favor, particularly as contrasted with

psychophysical models. In the latter models, there is no such thing as risk. Although they predict risky choice, they are silent on judgments of risk. Intuitively, however, risk plays a role in risky choice. Risk is the absence of security; security is the absence of risk. Seems simple enough.

B. Risk Attitude Is More Than the Psychophysics of Money

The second bit of support for the theory is that it can predict the preferences of both risk averse and risk seeking people. In experiments 1 and 2 of Lopes (1984), subjects were shown various pairs of lotteries and asked to say which they would prefer to play. The subjects were then divided according to whether or not they tended to take the sure thing when it was offered. Risk averse subjects (i.e., those subjects who took the sure thing 8 or more times out of 10) had preferences that were essentially perfectly predicted by security motivation (i.e., they preferred lotteries whose Lorenz curves lay near the diagonal at the low end.) Risk seeking subjects (i.e., those who took the sure thing 3 or fewer times out of 10) had preferences that were for the most part predicted by potential motivation (i.e., they preferred lotteries whose Lorenz curves lay far from the diagonal at the high end).

The ability to account for people whose choices are primarily risk seeking is another benefit of the two factor theory. Psychophysical theories and moments theories are theories of Everyman because they are based mechanistically on principles that should hold for us all: "our perceptual apparatus is attuned to the evaluation of changes or differences" (Kahneman & Tversky, 1979, p. 278); "uncertainty...has a disutility growing worse with increasing speed when [the] standard deviation [of utilities] increases" (Hagen, 1979, p. 274). But Everyman is risk averse for gains even though every man (or woman) is not[9]. Two factor theory puts risk seekers and risk averse people on equal footing. Although their choices may differ profoundly, their choice <u>processes</u> have more similarities than differences. They understand risks in the same way (cumulatively) and they trade off the same factors. Their goals may differ, but they have the same conceptual equipment.

C. Risky Choice Is Not Conflict Free

The best evidence for the two factor theory comes from a recent study of the preferences of preselected risk averse and risk seeking subjects for gain and loss lotteries (Schneider & Lopes, in press). Subjects were selected from a large group of undergraduates who had filled out a brief questionaire asking for their preferences in five choice pairs. Each pair contained a positive two-outcome gamble and a sure thing of equal expected value. In accord with conventional usage, risk averse subjects were defined as those who selected the sure thing every time, and risk seeking subjects were defined as those who selected the gamble at least four times. Thirty subjects were selected from each group.

The 10 stimuli in the experiment included the 6 stimuli in Figure 1 plus a $100 sure thing. Subjects were given the stimuli in all possible pairs and asked for their preferences. The pooled data are in Figures 8 and 9 for risk averse and risk seeking subjects, respectively. The stimuli from Figure 1 and the sure thing are listed on the abscissa by letter codes (ST = sure thing, RL = riskless, SS = short shot, PK = peaked, RC = rectangular, BM = bimodal, LS =

long shot). The lotteries identified by number were an additional riskless lottery (2), an additional short shot (4), and an additional long shot (8). The open symbols are for gain lotteries and the filled symbols are for loss lotteries.

Insert Figures 9 and 10 about here

Looking first at the risk averse subjects, it is clear that their preferences for gains decrease essentially monotonically from the sure thing to the long shot. Their preferences for losses, however, have an inverse-U pattern, being low for the sure thing and the riskless lotteries (at the left) as well as for the long shots (at the right). These qualitative patterns (which were highly reliable statistically) are exactly what the two factor theory predicts (cf. Table 1). For gain lotteries, security and aspiration support the same choices, producing monotonicity. For losses, however, security and aspiration conflict, producing nonmonotonicity.

The risk seeking subjects also follow the pattern predicted by the two factor theory. Their preferences are essentially monotonically increasing from the sure thing to the long shot for losses, but vary complexly for gains. Worst liked are the sure thing, the short shots, and the peaked lotteries; long shots and riskless lotteries are better liked. These patterns were also highly reliable statistically.

Considering the crudeness of the estimates used in Table 1, the fit is remarkably good. Both groups like RL a little better than they should for gains, and risk seekers like long shots a little less well than they should for losses, but the overall picture is as it should be. The presence of nonmonotonicity in both data sets confirms the existence of conflicting factors in risky choice. And the mirror-symmetry between the two subject groups confirms their structural similarity. They are basically doing the same thing, but their values differ at least on security/potential and probably on aspiration level as well.

VI. The Things We Don't Talk About

Psychologists who study risky choice <u>don't</u> talk about a surprisingly large number of factors that are psychologically relevant in choosing among risks. Given the poverty of our theoretical language, it is, perhaps, surprising that we manage to talk at all. Here are some words that are not to be found in the theoretical vocabulary: fear, hope, safety, danger, fun, plan, conflict, time, duty, custom. Nor can these words be given meaning in psychophysical theories. The language of psychophysics is the language of perceptual distortion. It has room neither for the experience of emotion (fear, hope, fun), nor for the physical context in which risks occur (safety, danger), nor for the social constraints on individual action (custom, duty), nor for the cognitive activity of the chooser (plan, conflict).

Distributional theories, on the other hand, can express these meanings easily. Oddly, however, it was an economist (Hagen, 1969) who identified skewness with hope and fear whereas psychologists working with similar

theories (Coombs, 1975; Coombs & Lehner, 1981; Luce, 1980; Pollatsek & Tversky, 1970) have shied away from using such language. Queasiness about the ordinary language of emotion and intention goes back in psychology at least to Watson's behaviorist manifesto, and in the area of risky choice has been amplified by exposure to a similar movement in economics termed <u>positive economics</u> (Friedman, 1953). In fact, modern economic expected utility theory (von Neumann and Morgenstern, 1947) has relegated even the classical psychophysical concept of utility to the status of an epiphenomenon. In the modern view, utility does not precede and cause preferences; it is, instead, merely a convenient fiction that can be used by the practitioner to summarize the preferences of those who, by choice or chance, follow the dictates of the von Neumann and Morgenstern axiom system.

If however, hope and fear and plans are necessary ingredients in risky choice, then it is not unscientific to talk about them. Many social scientists working outside the narrow confines of the laboratory or the mathematical proof treat these terms casually, like old friends. In the remainder of this paper I draw on these broader approaches to risk and show their relation to the two factor theory.

A. Fear and the Safety-First Principle

Psychophysical theories of risky choice do without a psychological concept of risk, but people cannot. Risk is a fact of our physical and social environments. This is nowhere more clear than in agriculture, particularly subsistance agriculture in which one's livelihood can be literally threatened from all sides (by floods, by pests, by invading armies). Agricultural economists look at risk quite differently than either psychologists or those economists who have influenced psychology most strongly in recent years. For the agricultural economist, both risk and risk aversion are real. The behavior is connected to the phenomenon by a simple rule called the safety-first principle.

The subsistance farmer is in a difficult position. Food crops provide food for the table and have low variance of return, but their expected return is also low. Cash crops are more variable but have higher expected return. The problem is how much of each crop to plant. Although many different models of farmers' choice processes have been developed (Anderson, 1979), they all boil down to a simple rule: first take care of subsistance needs (food for the larder and seed for the coming season) and then plant cash crops. Although the farmer's world may be risky, the farmer does not view himself as gambling. In Ortiz's (1979) words, "The peasant's preference for subsistence over starvation cannot be rephrased into a preference for $\underline{X}$ chance of $\underline{Y}$ income over $\underline{X}$-$\underline{n}$ chance of $\underline{Y}$-$\underline{m}$ income; such paraphrasing totally misrepresents his options and it is unnecessary" (p. 235).

It should also be noted that although fear feeds risk aversion, risk-taking can be fed either by hope or by necessity (see Section IV.B). Conventional economic theory treats risk-taking as a luxury. Neither individuals nor firms are supposed to indulge in it unless they can afford it. Kunreuther and Wright (1979), however, have pointed out that sometimes the poorest farmers devote as large a proportion of their land to cash crops as the richest farmers. Likewise, Bowman (1982) has demonstrated that

economically troubled firms often engage in riskier behavior than economically sound firms. In both these cases, risk seeking behavior is interpreted as arising from necessity. If there is not enough safety even when safety is put first, the risky choice may be the only choice.

The connections between safety-first and the two-factor theory are obvious. The safety-first principle aims at security. A target level is set and choices are made so as to maximize the probability of achieving the target. The resulting choices are "cautiously suboptimal" (Day, 1979). However, risk-taking behavior may predominate when the aspiration level cannot be achieved safely. In neither case do the choices reflect the psychophysics of money or of chances. Nor are they merely the signs of pessimistic or optimistic world views. Farmers who follow the principle want (and need) to accept the risks of cash cropping, but they can do so only up to a point. Their choices reflect the planful activities of intelligent, though unsophisticated, people who know the odds and bet that way.

B. Planning Is Applied Hoping

The flip side of safety-first is entrepreneurship in which safety takes second place to opportunity. McClelland (1961) described entrepreneurs as people who display a willingness to take risks in situations in which their skills and effort can make a difference. The issue of control appears to be particularly important. Although spectators may judge that entrepreneurs take more risks than the average person, entrepreneurs see themselves as not being particularly risk prone (Keyes, 1985, pp.207-209; McClelland, 1961, p.222). This is also true of people who engage in physically risky professions or hobbies: "First they challenge fate, and then they try to bullwhip fate to its knees by making their adventure as predictable as possible. In fact, it's not adventure they're after. It's mastery" (Keyes, 1985, p. 115). Even in casino gambling where outcomes cannot be controlled, high stakes gamblers take pride in the control of their emotions (see for example, Alvarez, 1983, pp. 47, 169; Thackrey, 1968, pp. 62-63).

A lot has been written about control in recent years. Langer (1977) has synthesized an impressive body of experimental evidence documenting the fact that people behave as though they believe that chance events can be controlled. In her view, the illusion of control comes about for several good reasons: (1) people are motivated to master their environment, (2) it is unpleasant to believe that one has no control, (3) chance and skill elements coexist in many situations, and (4) the illusion can help us emotionally more than it can harm us practically.

One might suppose (as Langer has <u>not</u>) that risk-taking behavior is caused by the optimistic illusion that outcomes are more controllable than they really are. McClelland (1961), however, has argued that entrepreneurship is independent of optimism. He presents evidence from four different countries that school boys who are high in optimism are "conscientious, efficient, forward-looking, <u>managerial</u> types [who work] hard and efficiently at everything more or less indiscriminately" (p. 227-228), but they are not necessarily high in achievement motivation. A student who is high in achievement motivation works hard only on those things that can give a sense of personal responsibility. "If there is no challenge, he doesn't work so

hard: in this sense he would make a poor bureaucrat" (p. 228).

The belief that one can control one's fate appears to be necessary to good mental health (Abramson, Seligman, & Teasdale, 1978). When highly desired outcomes are believed to be unlikely or when highly undesirable outcomes are believed to be likely, and when the individual believes that nothing can be done to change these likelihoods, depression results causing attendant motivational and affective deficits.

Beliefs about control and motivation feed back on one another. When aversive events occur despite one's efforts to prevent them, motivation to control events is reduced both in animals (Maier & Seligman, 1966) and in humans (Hiroto, 1974; Hiroto & Seligman, 1975). When control is later made possible, the motivational deficit prevents learning from occurring. Responses that are not made cannot be reinforced. A vicious cycle results.

Feedback between control and motivation can also be positive. Sawyer (cited in McClelland, 1961, p. 222) has argued that self-confidence in individuals can lead to the very circumstances that are necessary to achieve success. He gives as an example the settling of the American West in the 19th century. Had not so many people behaved as though it was possible, it would <u>not</u> have been possible. Although individuals failed in large numbers, sufficiently many survived that settlement was collectively accomplished.

In the two-factor theory, people may be motivated by achievement (potential) as well as by security. McClelland (1961) stressed in his work that people who are high in achievement motivation do not like to gamble. That may be so in the narrow confines of two-outcome gambles presented in the laboratory. In the real world it seems unlikely that achievement motivated people could be obsessed by security. Although one cannot control the actual outcome in chance situations, one can control the likely outcome. This is what portfolio managers do in the investment field. Maximum return and maximum safety cannot both be had, but one can assemble portfolios that trade a little risk for an acceptable return. Balancing the unavoidable risks in one's personal portfolio is a skillful activity that should appeal to achievement motivated individuals.

C. Anticipation and Imagination

Uncertainty is embedded in time. There is a now in which some things are true, a future in which other things may be true, and a still farther future in which we may reflect on the past. At the point of choice we look forward along this track, and we also anticipate looking back. The temporal element is what gives risk both savor and sting.

Pope (1983) has criticized expected utility theory for having ignored the time between the decision and the resolution of the uncertainty, what she calls the pre-outcome period during which fear and hope operate. She points out that the period can be long not only for long-term decisions such as individuals choosing careers, governments embarking on social programs, and businesses making major capital investments, but also for repeat short-term decisions: "after deciding to devote a fraction of the housekeeping funds to

a weekly lottery ticket, housekeepers can dream from age nineteen to ninety-nine that they will become millionaires after the next drawing" (p. 156).

Uncertainty in the pre-outcome period can be pleasurable or unpleasurable. A traveler to Las Vegas may pay an extra fee to avoid the worrisome uncertainty of the $1,000 deductible on a rental car and then proceed at all speed to a casino in order to purchase the delightful uncertainty of gambling. Insurance cannot stop disaster from happening, but it can stop worry. Gambling cannot guarantee future bliss, but it can give hope. For small amounts of money we can enjoy the current psychological benefits of either in the same way that we enjoy other psychological commodities such as entertainment and convenience.

Decisions involving larger amounts of money and other sorts of serious consequences require us to extend our analysis beyond the time in which the uncertainty is resolved. Fears and hopes are then no longer relevant, but regret and disapointment are. Bell (1982, 1985) has argued that if we experience regret over decisions that turned out badly or disappointment over outcomes that fail to match up to expectations, these factors are as important to consider as more tangible monetary benefits and losses. "Psychological satisfaction, as opposed to the satisfaction derived from consumption, is an appropriate objective that should be included in any decision analysis if the decision maker regards it as a criterion for decision" (Bell, 1985, p. 26).

Decision makers also look to a future in which their preferences may change (March, 1978) and in which options not currently imagined may have become possible. Day (1979) has pointed out that farmers and business managers alike resist procedural changes that put them too far from current practice. This is a sensible rule for adapting to dynamic environments (both internal and external) since it leaves the old practice available as a fallback position should the new policy not produce the expected effects.

The importance of having safe fallback positions in real life may account for the fact that the perceived riskiness of technological hazards is not solely related to estimates of annual fatalities but also reflects dread of outcomes that are perceived to be uncontrollable, catastrophic, not easily reversed, and of high risk to future generations. Thus, intelligent but technically unsophisticated raters (students and members of the League of Women Voters) estimate fewer annual deaths from nuclear power than from home appliances but nevertheless consider nuclear power to be much more risky (Slovic, Fischhoff, & Lichtenstein, 1980, Tables 2 and 3).

Psychophysical theories of risk do not consider time, although one might conceive a psychophysics of future events. Economists use a similar notion (time preference rates) to handle the fact that money now is generally worth more than money later. But as Pope (1979) has argued, such a concept would deal only with changes in the worth of the final outcomes and not with the emotions that one experiences in the interim. Theories (such as the present theory) that recognize planning and conflict resolution as an integral part of risky choice can deal more naturally with such temporal factors both as they affect changes in the aspiration level and as they affect position on the security/potential dimension.

D. Sherpas and Other High Rollers

All life chooses among risks, though we do not ordinarily think of trees choosing how to gamble their seed or amoebas choosing whether to approach or avoid possible prey. For the lowest organisms, evolution has done the choosing and equipped them with prewired choices. For higher organisms, however, cognition increasingly intervenes, allowing learning and reason to override rote instinct. Humans are the most complex cognitively and exhibit responses to risk that sometimes have little to do with the satisfaction of immediate wants or needs. Among these are the responses of our social selves.

High standard mountaineering is incredibly risky. The chances of being killed on a Himalayan climb are about 1 in 10. Why is it done? What is there on the top of such mountains that anyone might want? Obviously, the answer is aesthetic, not practical, at least for the recreational climber (if such a word can be applied to so hazardous an avocation) who must expend considerable personal resources and obtain even more considerable institutional resources just to make the attempt.

But the Sherpas who carry the loads also share in the risks. Why do the Sherpas climb? The conventional view is that they climb out of economic necessity. Michael Thompson (1980), however, himself an Everest climber, disputes this distinction between Sherpa and non-Sherpa. In Thompson's view, risks that are pursued for practical purposes become tame in the process as has commercial air travel. But risks that are pursued for themselves do not become tame. Thus, for aesthetic purposes a proposed Everest route "is only felt to be worthwhile if there is considerable uncertainty as to its outcome" (p. 278). Sherpas also take this view and refer scornfully to the route that Hillary and Tenzing followed, the easiest of the routes for obvious reasons, as "the Yak route." A small joke among those who share a common aesthetic.

Risk taking is one of the ways we define ourselves psychologically and socially (Douglas and Wildavsky, 1982). It is a mistake to suppose even in the realm of financial risks that choice is a purely monetary matter. For entrepreneurs and high stakes gamblers alike, money is not the main thing. It is a way of measuring results, a way of keeping score (cf. Alvarez, 1983, p. 42; McClelland, 1961, p. 237; Thackrey, 1968, pp. 57-58). In the same way, many currently well-to-do people who grew up in the Great Depression continue to value security in a way that their more fortunate children cannot understand. A penny saved is not a penny saved; it is security in the bank.

Nor should custom and duty be forgotten in their effects on risk taking. Consider the story of the Reindeer and the Montcalm (Mowat, 1982). In March of 1932 the salvage tug Reindeer set to sea carrying 28 men in a furious storm to rescue a damaged freighter. Reindeer was not designed for such work and she was old and ill-equipped. Within hours she was foundering 60 miles from land. The vessel Montcalm, meanwhile, had been damaged herself by the storm and was running for harbor. When it became clear that no other ship could reach Reindeer in time, the master of Montcalm, Captain Rothwell, turned her back to sea. "It had been no easy decision. Montcalm carried sixty passengers and a crew of fifty, and their lives were all in Rothwell's care. The risk to them was real enough, but the death of Reindeer's men was sure unless that risk was taken" (Mowat, 1982, p. 46). Although Reindeer sank, all

were saved, even the ship's dog.

To understand such events requires a more comprehensive view than can be provided by the simple psychophysics of lives saved or lives lost (cf. Tversky & Kahneman, 1981) or even by the machinery of hope and fear. Reindeer was there because risk is the essence of salvage work. Rothwell was captain of Montcalm because he was capable of exercising the traditional duty that sailors bear to other sailors. Theories that attempt to explain all of risky choice in the narrow terms of purely perceptual or purely cognitive or purely motivational mechanisms will necessarily miss much of what impels people toward or away from particular risks. The factors that influence human risk taking range from psychophysics to society and from fear to fun. So too should the psychology of risk.

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1. Kahneman and Tversky (1979) call their function a "value function" to distinguish it from the utility function of modern expected utility theory (von Neumann & Morgenstern, 1947). Because this article deals primarily with the psychophysical or classical interpretation of utility, the single word "utility" is used throughout to refer to the subjective value of money or other commodities.

2. Originally the value was assumed to be .50, but now it is believed to be nearer .35 (J. Atkinson, 1983).

3. Researchers presumably also have limitations in their ability to process information. This might be an additional reason for preferring two-outcome gambles, though it doesn't get mentioned.

4. Hagen's (1969) theory is expressed in terms of the moments of the distribution of psychological or subjective values. In the present case, however, the relations among the moments of the objective distributions are similar to those that would obtain for the subjective distributions.

5. The variance is unchanged when a positive constant is added to each outcome in the distribution. Risk, however, decreases (Keller, Sarin, & Weber, in press). For example, if $1,000,000 were added to each of the outcomes in the various lotteries in Figure 1, their variances would be unchanged, but they would have become much more similar in terms of perceived riskiness. Would that we each could participate in such delightfully unrisky ventures!

6. The graphical analyses that are used in this paper apply only to lotteries having equal expected value. Although Lorenz curves can be drawn for lotteries that differ in expected value (by omitting the normalization step in column 7), comparisons of such Lorenz curves would need to take this into account. In such cases, comparison by means of a mathematical index of security or potential would probably be preferable (see Section IV.A).

7. It is worth noting that strategies that involve maximizing the probability of meeting a goal or aspiration level are fundamentally different from strategies of maximizing expected utility. In the utility formulation, necessity can only be captured by assuming that the utility function temporarily becomes positively accelerated in the region of the target value (see, e.g., Kahneman & Tversky, 1979, p. 279). Such explanations are obviously ad hoc since they can be called into play anytime the standard psychophysics of the situation cannot explain the preference. The alternative view that subjects sometimes attempt to maximize the probability of achieving aspiration levels has been taken by Allais (1979) and by Lopes (1981). Although this view seems to make intuitive sense, it violates the axioms of

expected utility theory and has been considered to be irrational for that reason (see, e.g., Samuelson, 1977, p. 48).

8. In cases of strong conflict involving extremely important outcomes (e.g., health issues, large financial transactions, career changes, etc.) conflict may be reduced by various psychological bolstering processes (Festinger, 1957; Janis & Mann, 1977). Whether these entail distortion of values and probabilities during the choice process or selectional mechanisms operating in the construction of a post-decisional rationalization for the chosen alternative is an important question, but not one to which the present experiments can speak. Nevertheless, even if there is considerable distortion pre-decisionally, security/potential and aspiration level would still function in people's deliberations about the presumably distorted distributions.

9. One could, of course, explain individual differences within a psychophysical theory by supposing that people with different preferences have different utility and probability functions. This would, however, vitiate the claim that risky choices can be explained by basic perceptual processes. At the limit, the functions would become a means for summarizing preferences after the fact (as is the case for the von Neumann and Morgenstern, 1947, utility function), but such functions would lack predictive and explanatory power.

Table 1
Hypothetical Preferences for Risk Averse and Risk Seeking Individuals for Gain and Loss Lotteries

Risk Averse Individual

	Gain Lotteries				Loss Lotteries			
LOT	AL	SEC	SEC x AL	REL PREF	AL	SEC	SEC x AL	REL PREF
ST	1.00	1.00	1.000	.310	0.00	1.00	.000	.000
RL	1.00	0.83	0.830	.257	0.00	0.58	.000	.000
SS	0.90	0.58	0.522	.162	0.10	0.83	.083	.284
PK	0.90	0.58	0.522	.162	0.10	0.58	.058	.199
RC	0.75	0.33	0.248	.077	0.25	0.33	.083	.284
BM	0.60	0.17	0.102	.032	0.40	0.17	.068	.233
LS	0.47	0.00	0.000	.000	0.53	0.00	.000	.000

Risk Seeking Individual

	Gain Lotteries				Loss Lotteries			
LOT	AL	POT	POT x AL	REL PREF	AL	POT	POT x AL	REL PREF
ST	1.00	0.00	0.000	.000	0.00	0.00	.000	.000
RL	0.69	0.42	0.290	.143	0.00	0.17	.000	.000
SS	0.78	0.17	0.133	.065	0.03	0.42	.013	.022
PK	0.74	0.42	0.311	.153	0.02	0.42	.008	.013
RC	0.60	0.66	0.396	.195	0.10	0.66	.066	.111
BM	0.52	0.83	0.432	.213	0.24	0.83	.199	.333
LS	0.47	1.00	0.470	.231	0.31	1.00	.310	.520

Note. Rows are ST (sure thing), RL (riskless lottery), SS (short shot), PK (peaked lottery), RC (rectangular lottery), BM (bimodal lottery), and LS (long shot). AL is probability of achieving the aspiration level. SEC is security and POT is potential. REL PREF is relative preference.

Figure Captions

1. Examples of utility functions with four different shapes. The Bernoullian function (upper left) is uniformly risk averse (negatively accelerated). The functions in the upper right, lower left, and lower right (suggested by Friedman and Savage, 1948, Markowitz, 1952, and Kahneman and Tversky, 1979, respectively) have regions of risk aversion (negative acceleration) and risk seeking (positive acceleration). The upper two functions range from zero assets to large positive assets. The lower two functions range about a customary asset level (e.g., the status quo).

2. Examples of stimulus lotteries for gains. Each lottery has 100 tickets (represented by tally marks) and each has an expected value of approximately $100. The values at the left give the prizes that are won by tickets in that row. The lotteries are ordered from the upper left to the lower right in the order that they are preferred by risk averse subjects.

3. Demonstration of how to draw the Lorenz curve for a lottery. The panel on the left shows how probabilities and relative gains can be cumulated for the peaked lottery. The panel on the right gives the Lorenz curve. This plots the cumulative probability on the abscissa and the cumulative proportion of the winnings on the ordinate.

4. Comparison of the Lorenz curves of the long shot (LS) and the short shot. Lorenz curves that lie near the diagonal at the low end (stippled area) have relatively few small outcomes. Lorenz curves that lie far from the diagonal at the high end (striped area) have a few extremely large outcomes or relatively many moderately large outcomes.

5. Comparison of the Lorenz curves for the riskless lottery (RL) and the short shot (SS). The fact that the curves cross one another indicates that RL is good both for avoiding small outcomes (stippled area) and for approaching large outcomes (striped area).

6. Comparison of Lorenz curves for the bimodal lottery (BM) and the long shot (LS). These lotteries are very similar at their low ends (stippled area) but very different at their high ends (striped area).

7. Comparison of Lorenz curves for the bimodal (BM) and long shot (LS) <u>loss</u> lotteries. These lotteries are very different at their low ends (stippled area) but very similar at their high ends (striped area).

8. Comparison of Lorenz curves for the riskless (RL) and the short shot (SS) <u>loss</u> lotteries. The fact that the curves cross one another indicates that SS is good both for avoiding large losses (stippled area) and for approaching small or zero losses (striped area).

9. Mean preference data for risk averse subjects for gain lotteries (open symbols) and loss lotteries (filled symbols). Data are the number of times a subject chose a lottery out of the total number of times the lottery was available for choice. (From "Reflection in preferences under risk: Who and when may suggest why" by S. L.& Schneider and L. L. Lopes, <u>Journal of Experimental Psychology: Human Perception and Performance</u>, in press. Copyright 1986 by The American Psychological Association. Reprinted by

permission.)

10. Mean preference data for risk seeking subjects for gain lotteries (open symbols) and loss lotteries (filled symbols). Data are the number of times a subject chose a lottery out of the total number of times the lottery was available for choice. (From "Reflection in preferences under risk: Who and when may suggest why" by S. L.& Schneider and L. L. Lopes, Journal of Experimental Psychology: Human Perception and Performance, in press. Copyright 1986 by The American Psychological Association. Reprinted by permission.)

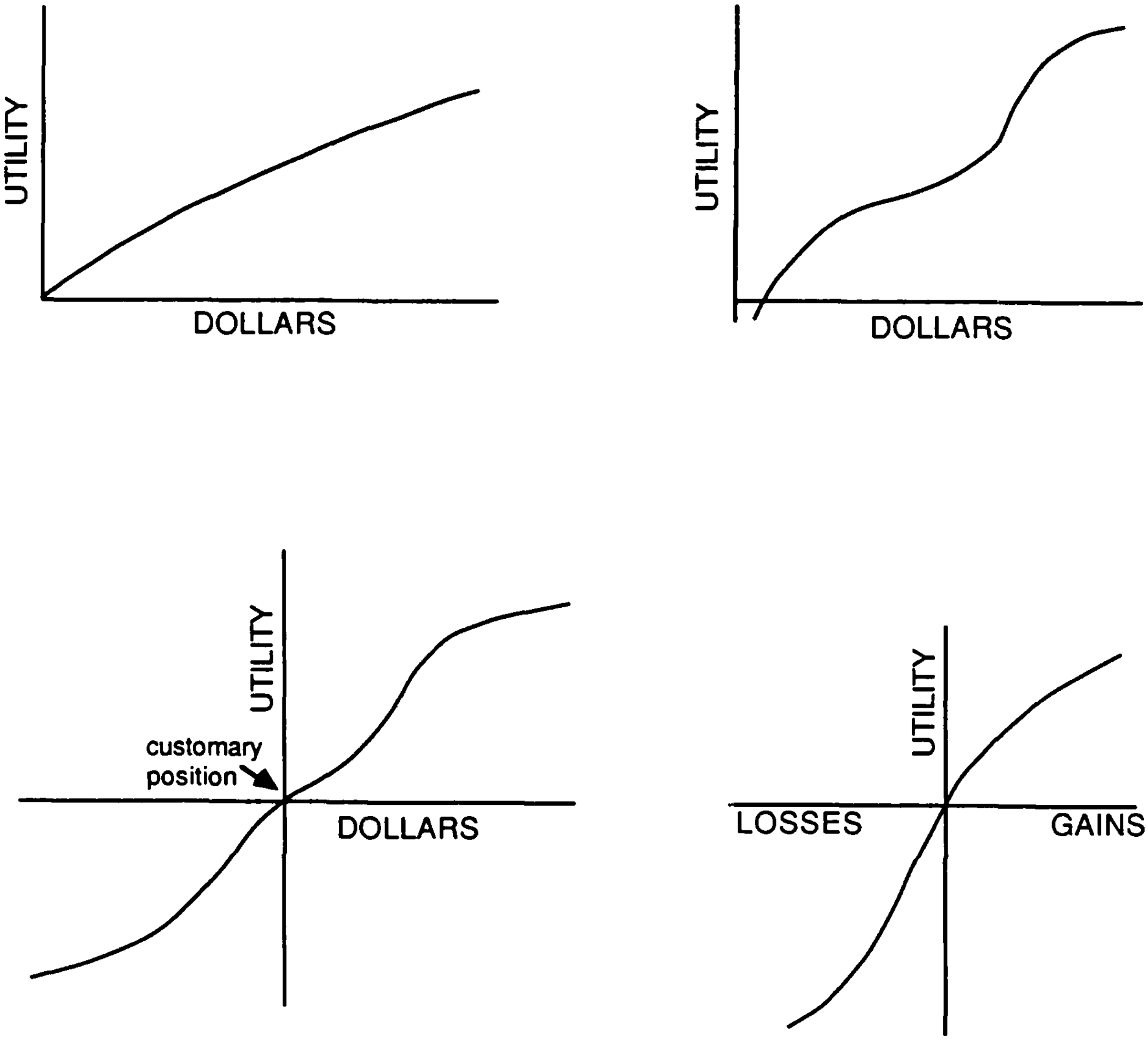
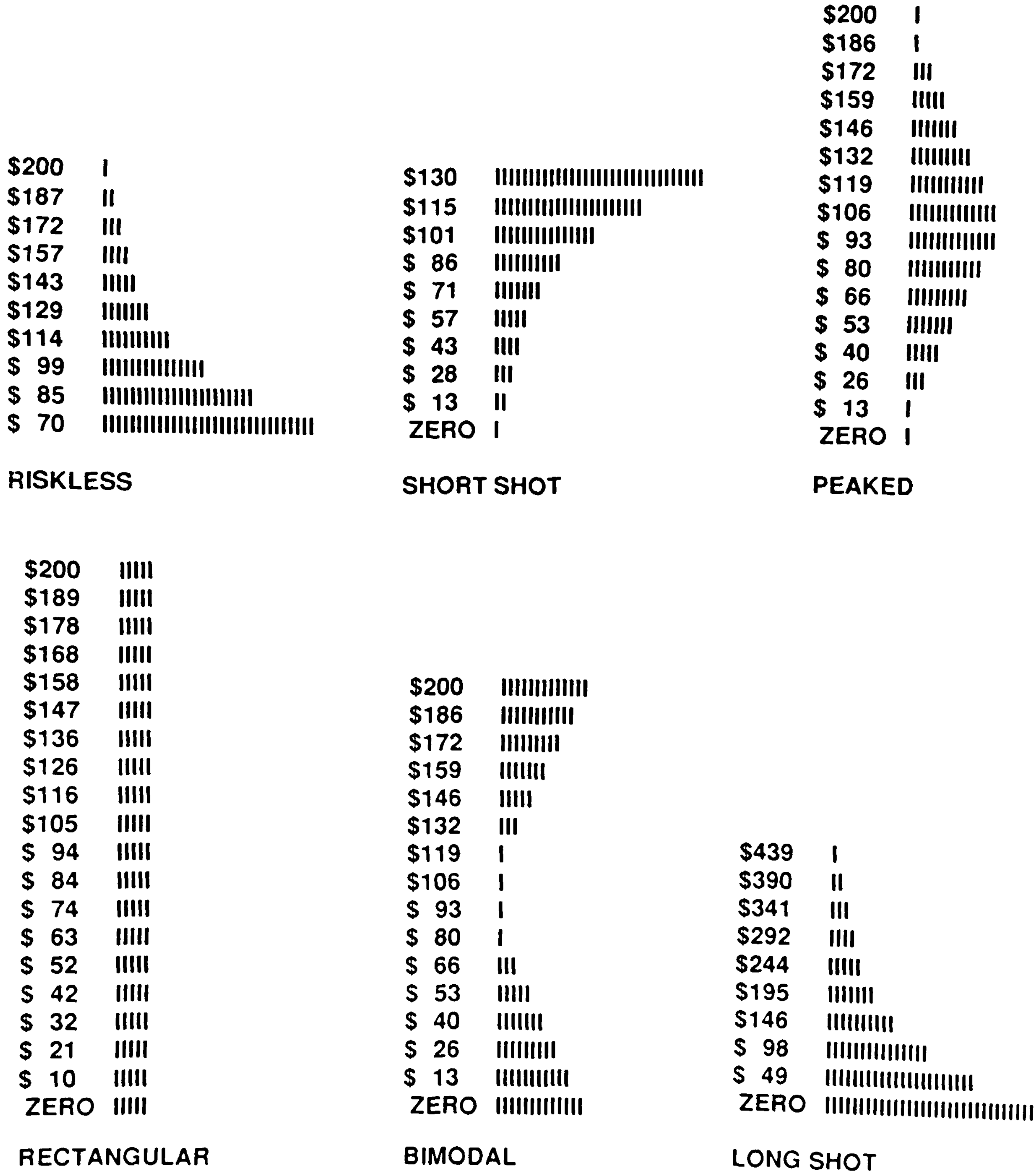

UTILITY
DOLLARS
UTILITY
DOLLARS
UTILITY
customary
position
DOLLARS
UTILITY
LOSSES
GAINS

Figure 1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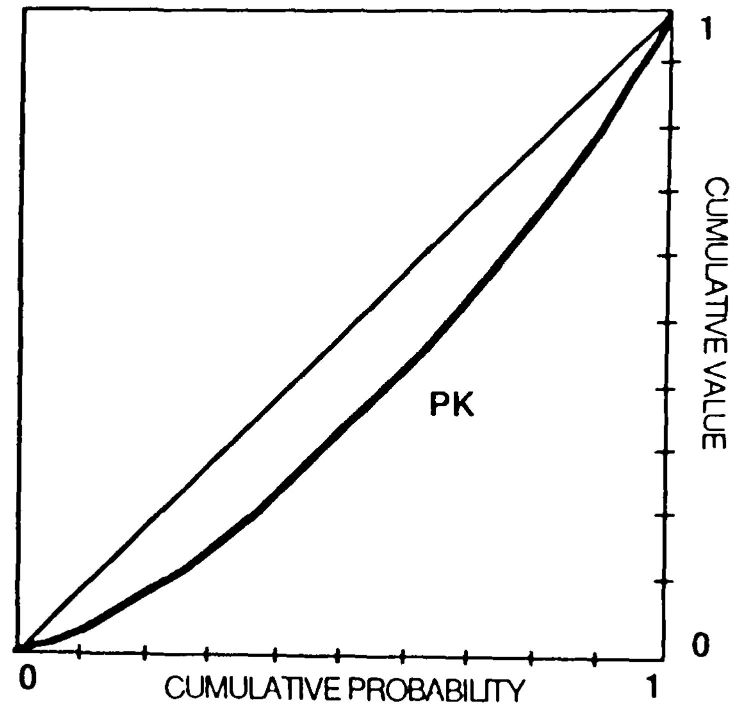
$172
$157
$143
$129
$114
$ 99
$ 85
$ 70
RISKLESS
$130
$115
$101
$ 86
$ 71
$ 57
$ 43
$ 28
$ 13
ZERO
SHORT SHOT
$200
$186
$172
$159
$146
$132
$119
$106
$ 93
$ 80
$ 66
$ 53
$ 40
$ 26
$ 13
ZERO
PEAKED
$200
$189
$178
$168
$158
$147
$136
$126
$116
$105
$ 94
$ 84
$ 74
$ 63
$ 52
$ 42
$ 32
$ 21
$ 10
ZERO
RECTANGULAR
$200
$186
$172
$159
$146
$132
$119
$106
$ 93
$ 80
$ 66
$ 53
$ 40
$ 26
$ 13
ZERO
BIMODAL
$439
$390
$341
$292
$244
$195
$146
$ 98
$ 49
ZERO
LONG SHOT

Figure 2

PRIZES (P)	TICKETS (T)	PROB. (PR)	P x T	CUM PR.	CUM P x T	CUM P x T / TOT P x T
0	1	.01	0	.01	0	.000
13	1	.01	13	.02	13	.001
26	3	.03	78	.05	91	.009
40	5	.05	200	.10	291	.029
53	7	.07	371	.17	662	.067
66	9	.09	594	.26	1256	.126
80	11	.11	880	.37	2136	.215
93	13	.13	1209	.50	3345	.337
106	13	.13	1378	.63	4723	.475
119	11	.11	1309	.74	6032	.607
132	9	.09	1188	.83	7220	.726
146	7	.07	1022	.90	8242	.829
159	5	.05	795	.95	9037	.909
172	3	.03	516	.98	9553	.961
186	1	.01	186	.99	9739	.980
200	1	.01	200	1.00	9939	1.000



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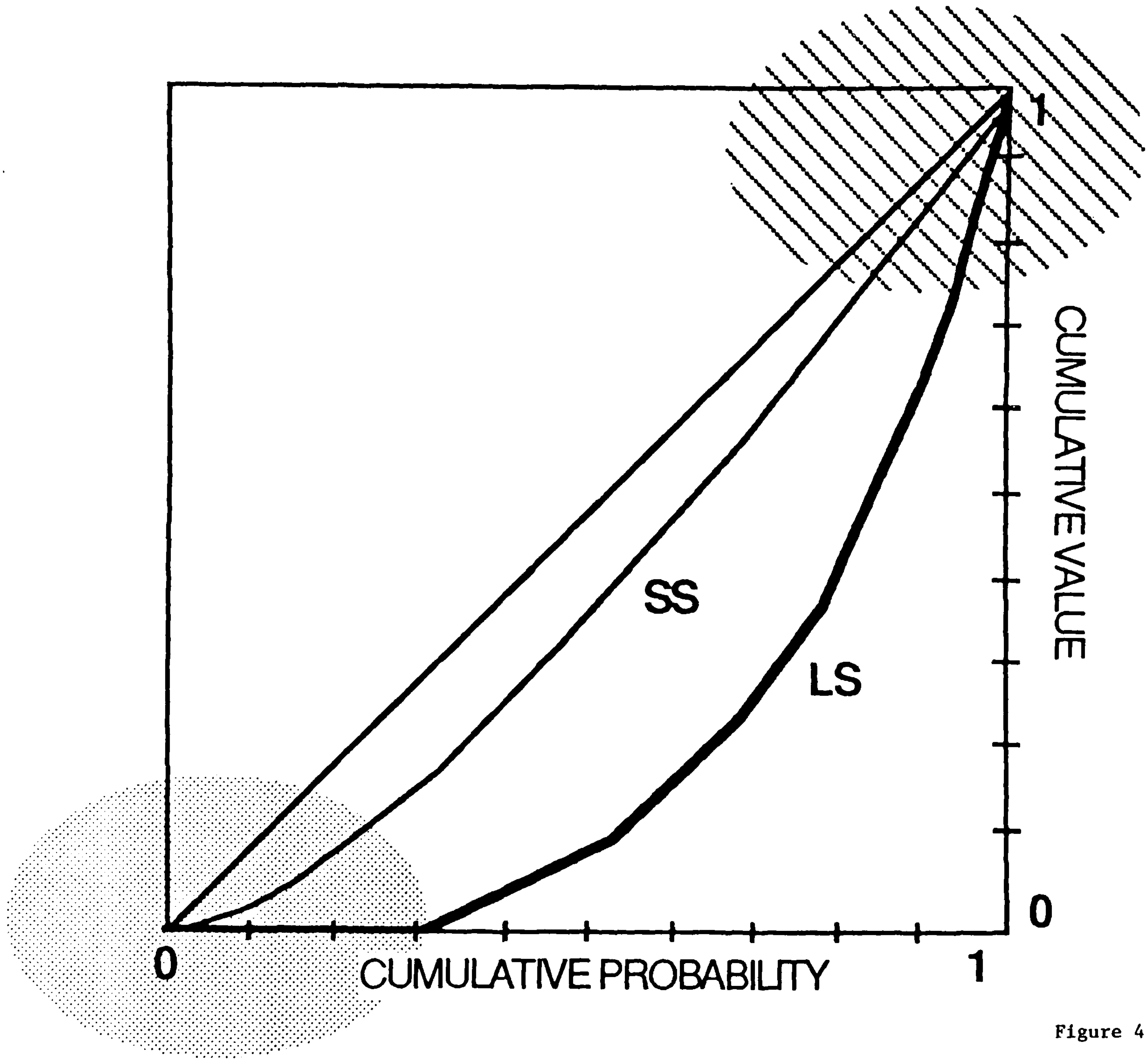

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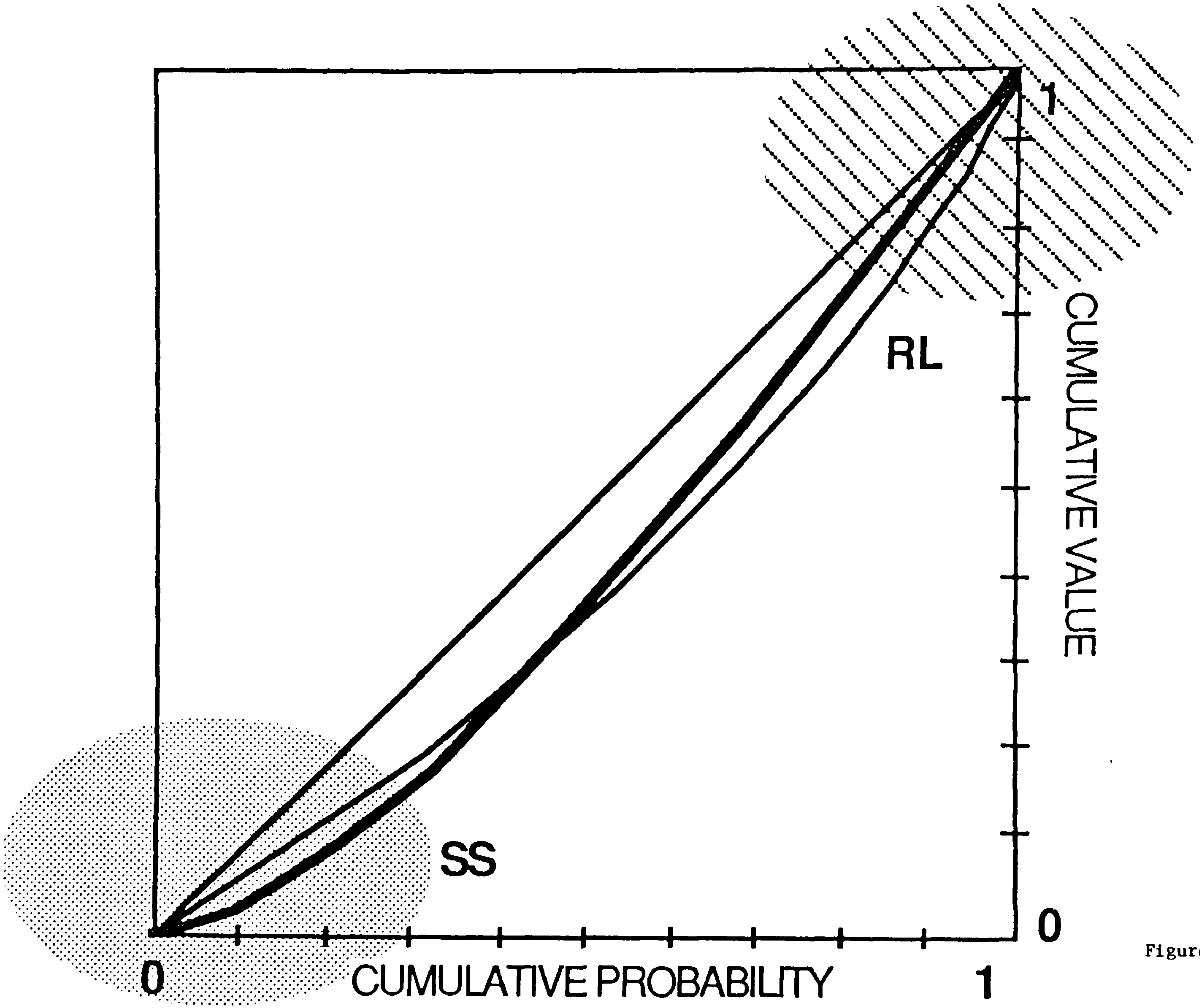

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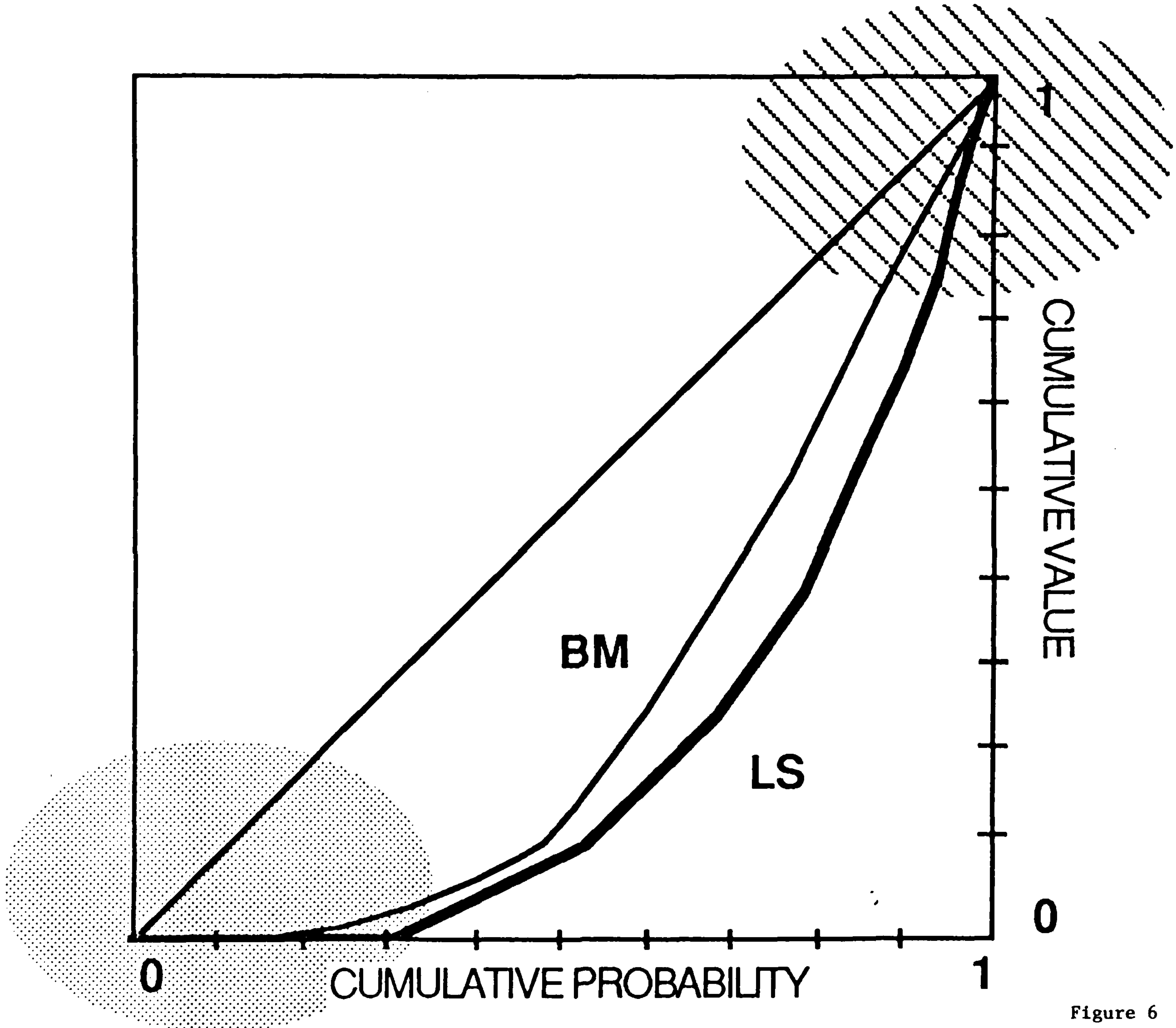

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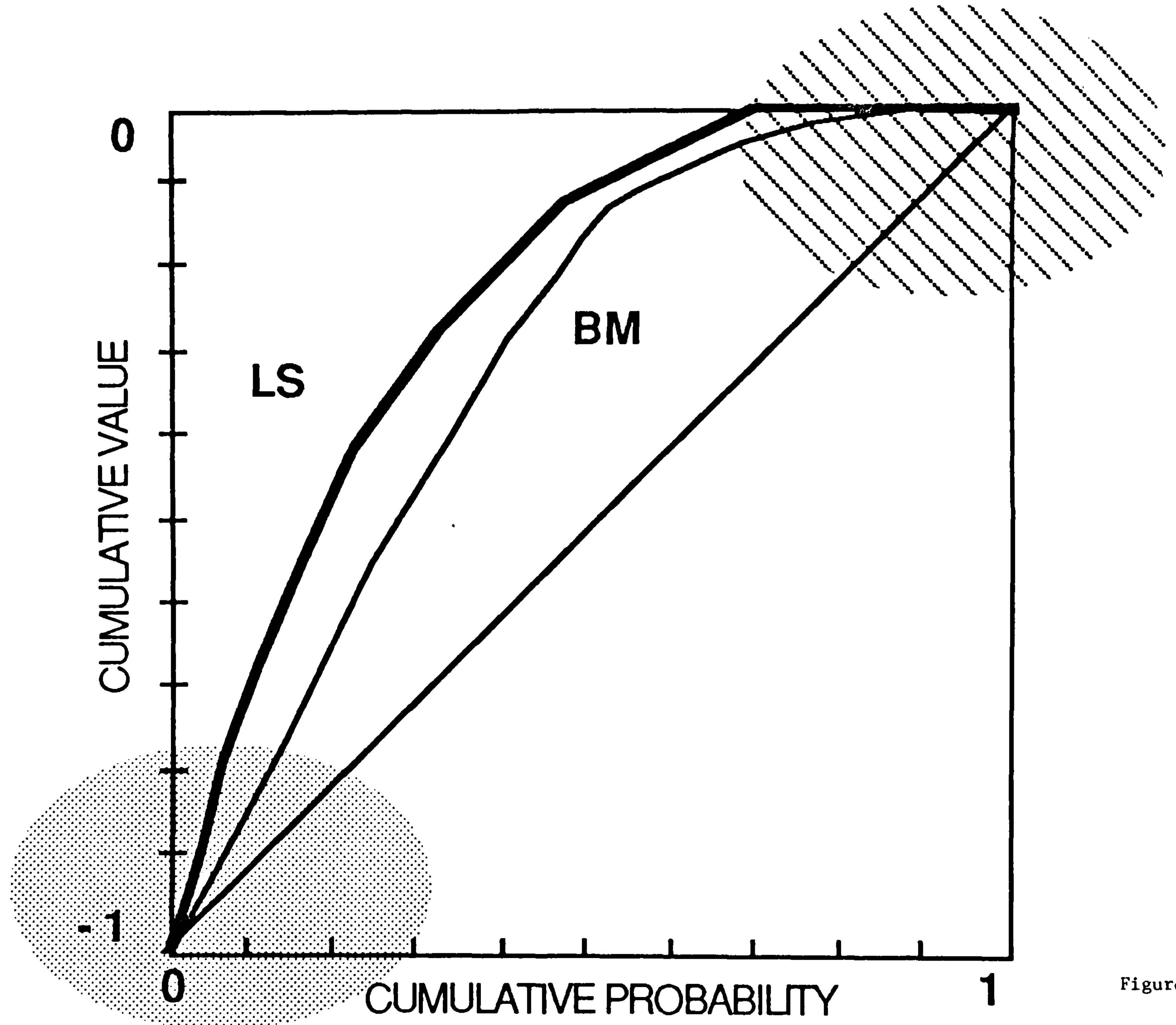

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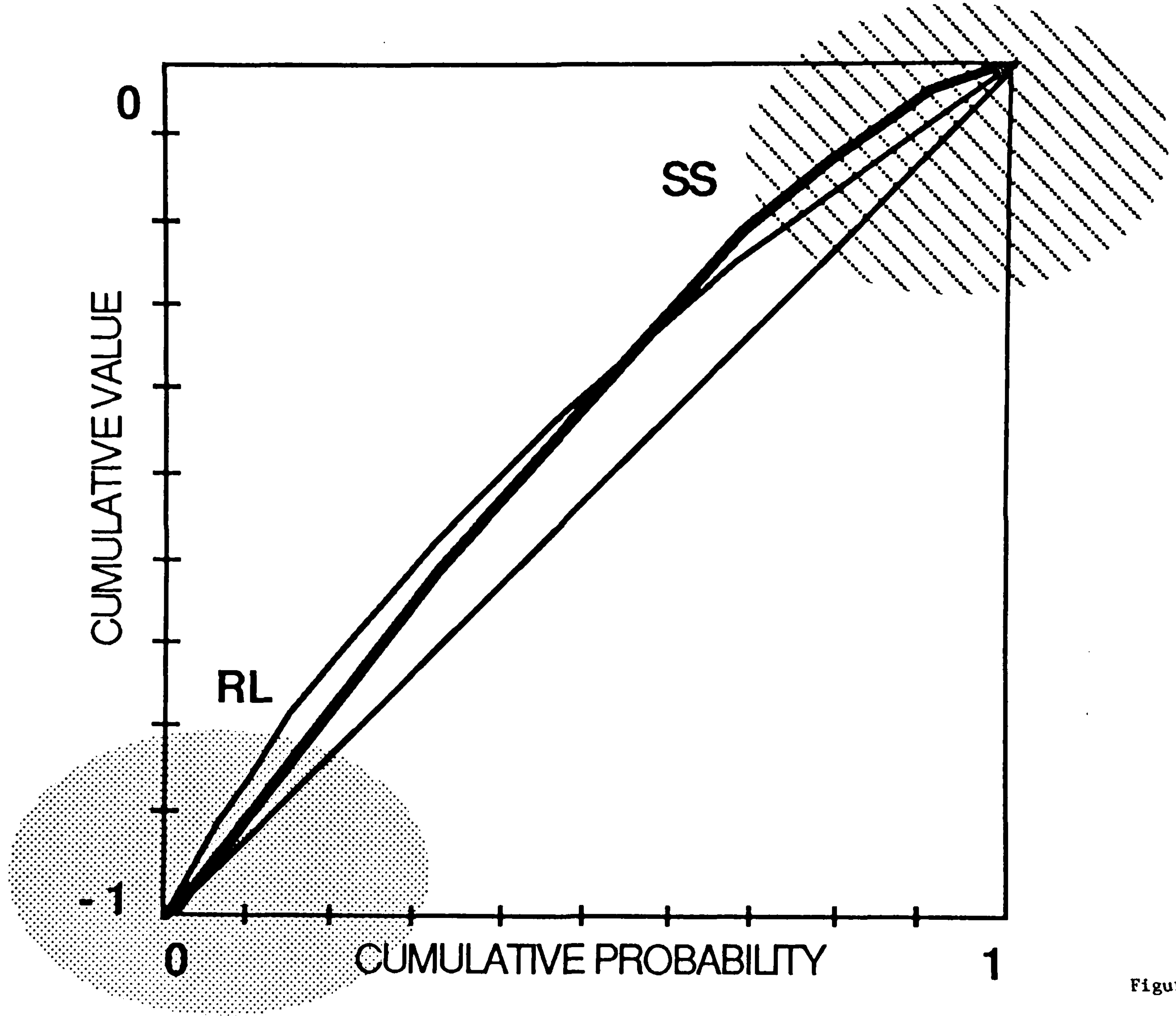
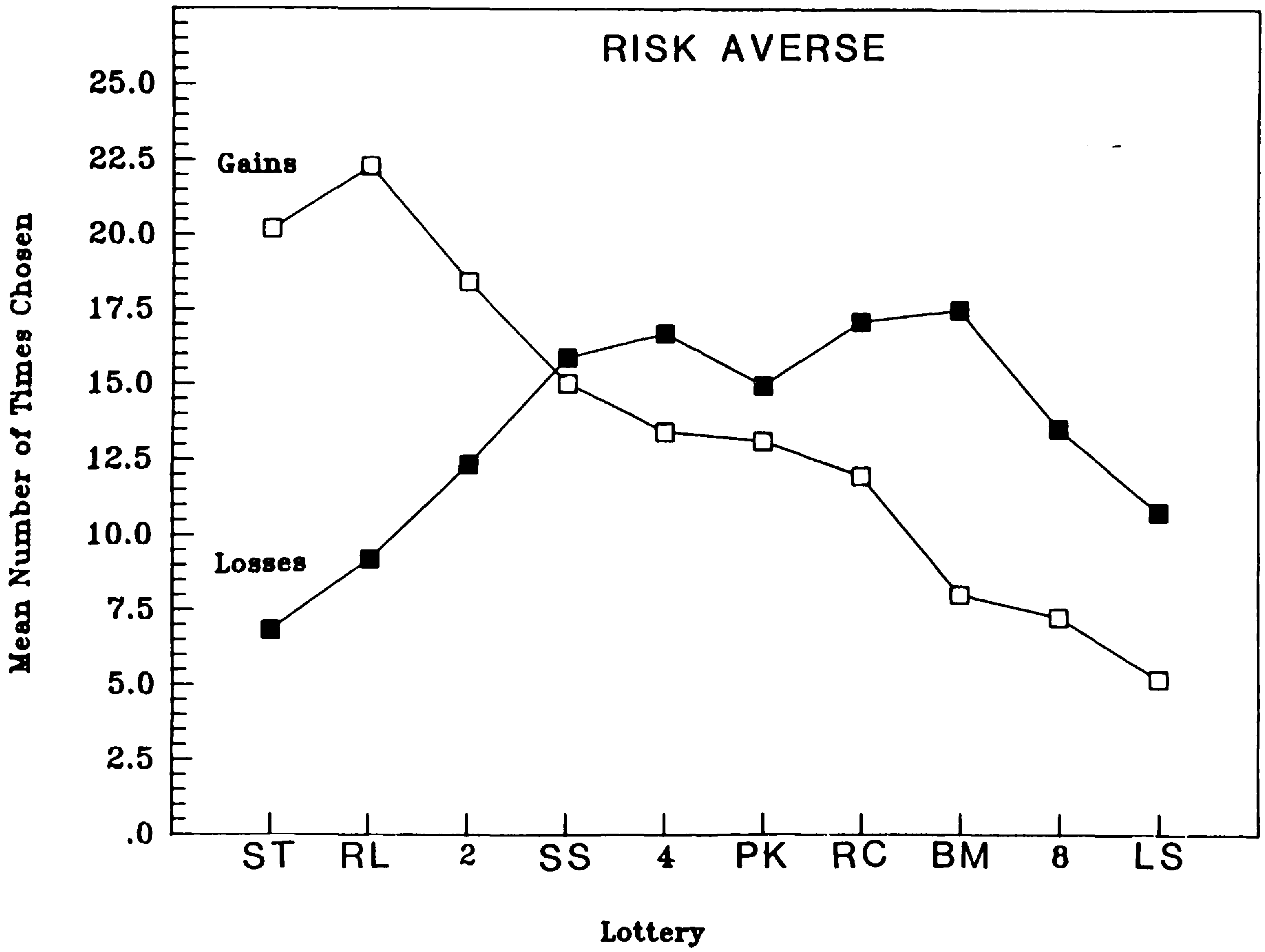


Figure 8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Gains
Losses
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
.0
ST
RL
2
SS
4
PK
RC
BM
8
LS
Lottery
Mean Number of Times Chosen

Figure 9

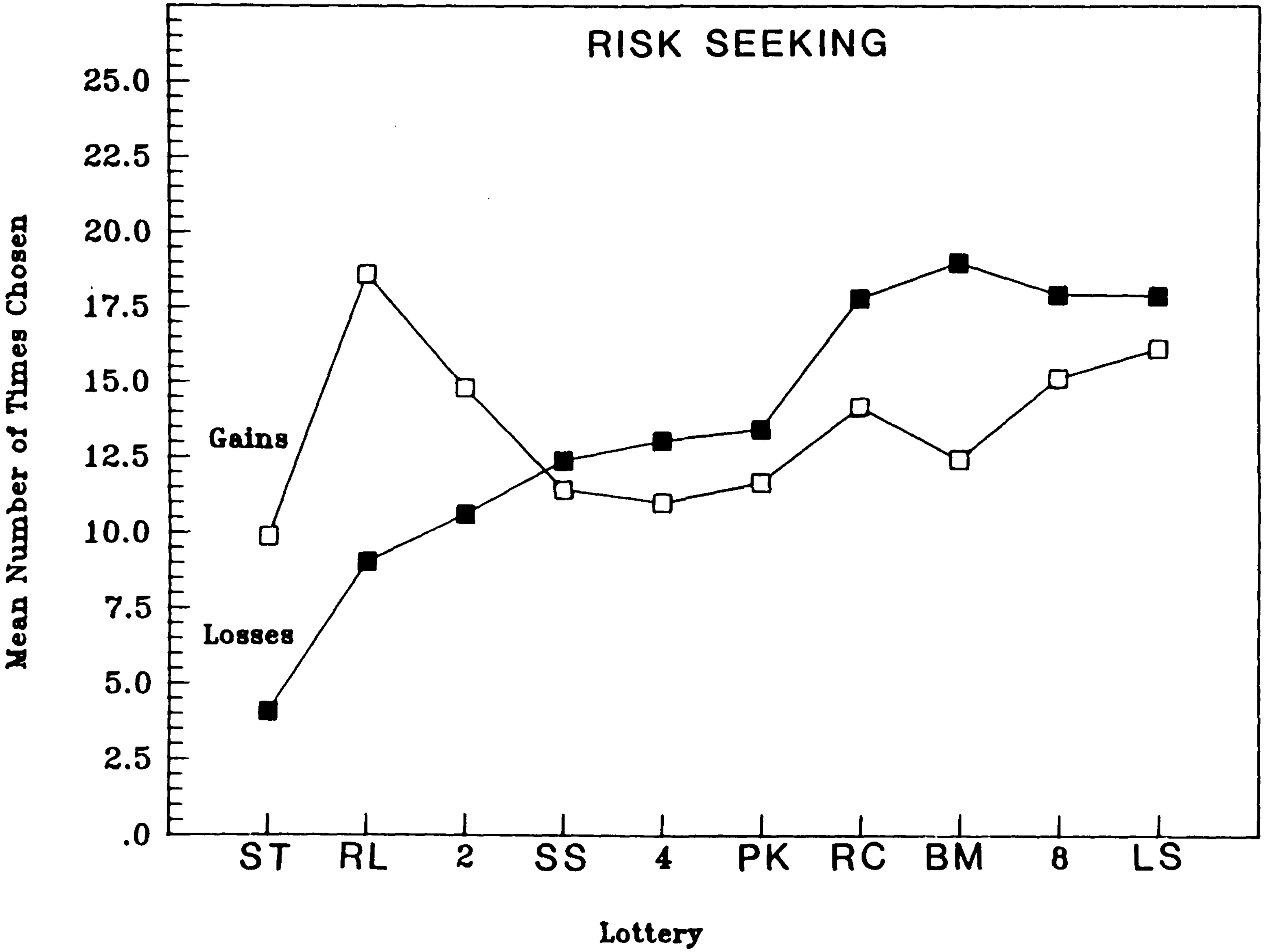
RISK SEEKING
Mean Number of Times Chosen
25.0
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
.0
Gains
Losses
ST
RL
2
SS
4
PK
RC
BM
8
LS
Lottery

Figure 10

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